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THE TOTAL SOLAR ECLIPSE OF AUGUST 21, 1914.

By N. N. JEWDOKIMOFF.

The path of totality of this eclipse passed through European Russia from Riga through Kiev and Theodosia and on through Trebizond and Asia Minor. For the purpose of observing this eclipse an expedition was equipped by the University Astronomical Observatory of Kharkov, Russia. The principal object of this expedition was to obtain photographs of the solar corona and also to photograph the partial phase of the eclipse for the determination of the diameter of the moon and of the correction to the moon's place at the time of the eclipse. Because of insufficient equipment at the observatory at Kharkov, no spectroscopic observations were planned.

Nearly all of the Russian and foreign expeditions had selected the city of Theodosia in the Crimea as the site for their observations. In order to prevent a concentration of too many expeditions in one place, we went to the small town of Genichesk on the shore of the sea of Azov Its situation with respect to the central line of the eclipse and its climatic conditions were quite as favorable as at Theodosia. The nearest other party was that of the Russian Astronomical Society under Mr. F. Blumbach, which was stationed about 15 kilometers farther south.

The geographical coördinates of our station at Genichesk were determined by Mr. Otto Struve with a Wanschaff transit instrument, as follows:

$$\phi = \quad 46^\circ\ 10'\ 06''.39 \pm 0''.23 \text{ (mean error)}$$
$$\lambda = \text{E.} \quad 2^h\ 19^m\ 15^s.37 \pm 0^s.21 \text{ (mean error)}$$

The time determinations were placed in charge of the same observer.

Two principal instruments were used in photographing the solar corona. One, for the outer corona, was an astrograph of short focus consisting of a Zeiss Astropetzval having an aperture of 12 cm. and a focal length of 55 cm. This astrograph was attached to a 6-inch visual refractor, equatorially mounted and provided with a driving clock. It was operated by Professor N. N. Jewdokimoff and Mr. B. P. Gerassimovich.

For the photography of the inner corona a special objective was or-

dered from Carl Zeiss in Jena. It consisted of UV glass, having an aperture of 10 cm and a focal length of 368 cm. This lens was mounted horizontally and used in connection with a plane mirror of the same aperture, made for this purpose by Carl Zeiss and mounted in a coelostat. The horizontal camera was used also for photographing the partial phase of the eclipse. This instrument was operated by Professor Ludwig Struve, then director of the Observatory, and by Messrs. K. G. Hintze and O. Struve.

The brightness of the corona in various position angles and distances from the sun was determined by Messrs. Fessenkov and Boshko. Mr. Fessenkov's results, obtained with a surface photometer of his own construction, are published in *Astronomische Nachrichten*, **220**, 187, 1924.

Visual observations of the contacts and of the corona were made by several other observers with small instruments.

On the morning of the day of the eclipse weather conditions seemed exceedingly unfavorable, but as noon approached the clouds began to disappear. The first contact was lost because of clouds, but ten minutes later the sky was clear and remained so until the end of the eclipse.

One of the exposures obtained with the short focus camera is here reproduced (Fig. 1). It was made at the beginning of the total phase on a Wratten panchromatic plate and in connection with a Wratten tricolour filter. The exposure time was 20 seconds: from $3^h\,14^m\,1^s.5$ until $3^h\,14^m\,21^s.5$, local mean time.

A laboratory test of the green filter used for this exposure was made by Gerassimovich. It appears to be slightly transparent for wave-lengths between 478 μ to 486 μ and for wave-lengths between 589 μ to 617 μ. The maxima of the transparency curve are in the two regions 486 μ to 587 μ and 656 μ to 686 μ.

Six exposures of the total phase were made with the horizontal camera. Because of the civil war in Russia, during which the city of Kharkov was several times the battleground of hostile armies, the original notebook of Professor Struve was lost and the accurate times of the beginning and of the end of each exposure are not known. The exposure times and the kind of plate used for each exposure are known from the preliminary program preserved in the files of the observatory. These data are given below.

No.	Exposure-time.	Plate.
1	2^s	Ilford, Special Rapid.
2	4	Wratten panchromatic.
3	4	Panchromatic, with yellow filter, transparent for light between 520 μ to 660 μ.
4	15	Ilford, Special Rapid.
5	8	Kodak, Extra Rapid.
6	4	Panchromatic.

Exposures 1, 2, 4, 6 of the foregoing list are reproduced on the accompanying plates.

In addition to these, 97 plates were obtained of the partial phase of the eclipse.

The contacts were observed by Jewdokimoff as follows:

Contact.	Local mean time.	Remarks.
	h m s	
Second Contact	3 13 57.05	
Third Contact	16 1.55	uncertain
Fourth Contact	4 20 32.58	

Kharkov, Russia, May, 1924.

THREE-PLACE COMPUTATION OF ZENITH DISTANCES.

By WILLARD J. FISHER.

Having occasion to compute a large number of zenith distances of the moon, with a precision which need in no case exceed 0°.1, I cast about for methods of doing this with three-place functions; these are entirely sufficient, and are contained on a single printed page.

The problem of finding zenith distance, given observer's latitude and longitude and the corresponding celestial position of a heavenly body, is a familiar one in nautical astronomy; it depends on the equation

$$\cos z = \sin\phi \sin\delta + \cos\phi \cos\delta \cos P \qquad (1)$$

where z = zenith distance, ϕ = latitude, δ = declination, P = hour angle of the body observed. In navigation it is generally solved with 5-place tables, or with the large special tables of Ball, Aquino, or others.

This equation may be computed directly, with logarithms and either addition-subtraction logarithms or natural functions; or it may be modified into

$$\cos z = \cos(\phi - \delta) - (1 - \cos P)\cos\phi \cos\delta \qquad (2)$$

which is good for this purpose, using 3-place natural cosines, with a slide rule for the multiplication. Generally the cosines may be taken from the sine scale of the slide rule, reading it backwards.

With only three decimal places, arithmetic is nearly as convenient as a slide rule, if contracted multiplication is used, and if (2) is altered into

$$\cos z = \cos(\phi - \delta) - (1 - \cos P)/2 \cdot [\cos(\phi - \delta) + \cos(\phi + \delta)] \qquad (3)$$

This is also good with more than three places; with five places it requires only one nine page table, and its precision is better than 1′ for $z = 3°$, and about 0′.1 for $z = 20°$.

With three places these equations give a precision of about 0°.1, if $z > 33°$ or even somewhat less. But the precision is poor for small zenith distances, becoming great uncertainty when the zenith distance is near zero. To meet this case of small angles the approximation

$\cos x = 1 - x^2/2$ may be used, or (3) may be changed into the exact form

$$\sin^2 z/2 = \sin^2(\phi - \delta)/2 + (1 - \cos P)\ (\cos\phi \cos\delta)/2$$

which, for z and $(\phi - \delta)$ both small, reduces to

$$z^2 = (\phi - \delta)^2 + 2(1 - \cos P) \cos\phi \cos\delta. \qquad (4)$$

To use this a slide rule is sufficient. When the angles are in degrees

$$z^2 = (\phi - \delta)^2 + 81.04^2\ (1 - \cos P) \cos\phi \cos\delta. \qquad (5)$$

When the hour angle P is also small enough,

$$z^2 = (\phi - \delta)^2 + P^2 \cos\phi \cos\delta \qquad (6)$$

which is very accurate when the angles z, $\phi - \delta$ and P are less than 20°; the work of squaring and multiplication can be done wholly with a slide rule; no factor is needed for degrees; the precision with slide rule is about 1/500 of z at 20° and thereabouts, and gets rapidly better with smaller angles; below 5° the error of (6) is only a fraction of 1′. On account of the squares it is not well adapted for contracted multiplication.

Equations (2) or (3) and (6) supplement each other; if three places are used, they have about equal precision at $z = 25°$, and improve, (2) and (3) for larger angles, (6) for smaller.

Following are worked examples done by each formula. The first two are from a twilight problem; the last two are modified from star distances in "Stars and Sextants," referred to as "Book."

Equation (2) Slide Rule

P	93° 50.5′
δ	−11° 10.6′
ϕ	+48° 35.0′
$\phi - \delta$	59° 45.6′
$\cos(\phi - \delta)$	0.504
$1 - \cos P$	1.067
corrn.	0.694
$\cos z$	−0.190
z	100.9°
4-place	100.86°

Equation (3) Arithmetic

P	93° 50.5′
δ	−11° 10.6′
ϕ	+48° 35.0′
$\phi - \delta$	59° 45.6′
$\phi + \delta$	37° 24.4′
$\cos(\phi - \delta)$	0.504
$\cos(\phi + \delta)$	0.794
	2)1.298
	0.649
$1 - \cos P$ reversed	760.1
	649
	39
	4
corrn.	0.692
$\cos z$	−0.188
z	100.8°
4-place	100.86°

Equation (5) Slide Rule

P	27° 54.3′
δ	+62° 09.4′
ϕ	+56° 22.1′
$\phi - \delta$	5° 47.3′
	= 5.79—°
$1 - \cos P$	0.116
$(\phi - \delta)^2$	33.5
corrn.	197.8
z^2	231.3
z	15.22°
	= 15° 13′
Book	15° 14′ 31″

Equation (6) Slide Rule

P	2° 43.9′
	= 2.73+°
δ	+32° 03′ 25″
ϕ	+28° 12′ 30″
$\phi - \delta$	3° 50′ 55″
	= 3.848°
$(\phi - \delta)^2$	14.81
corrn.	5.58
z^2	20.39
z	4.51+°
	= 4° 30.9′
Book	4° 30′ 47″

THE CENTRAL LINE OF THE SHADOW.

By FREDERIC R. HONEY.

During the very short period of time which elapses between the beginning and the end of a total eclipse of the sun, the moon's motion

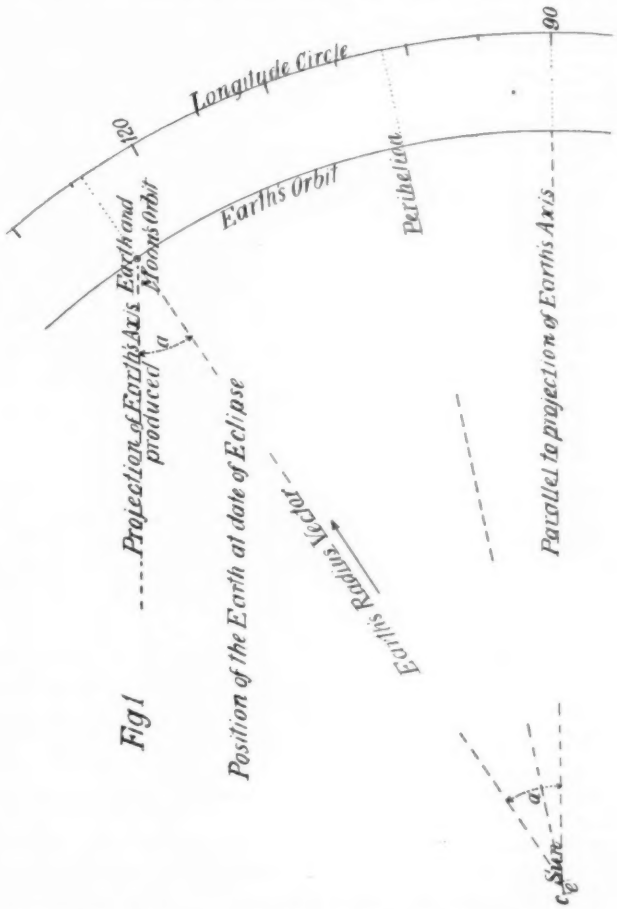
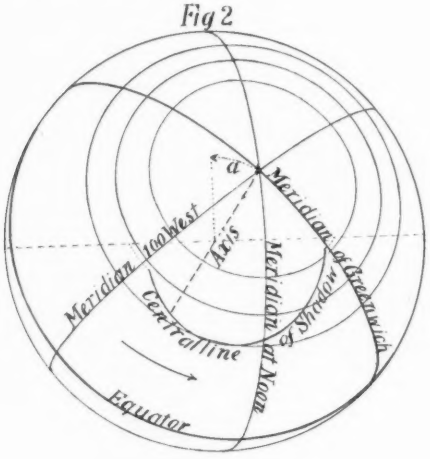


Fig 1

may be considered uniform; and since the earth's rotation on its axis is also uniform, if its axis were not inclined to the plane of the ecliptic, the determination of the path of the moon's shadow would be a com-

paratively simple construction. But, on account of the inclination of the axis, the parallels across which the shadow passes vary in latitude, and the surface upon which the shadow falls varies in velocity.

The accompanying illustrations are designed to assist the reader to realize the conditions which obtain in a total eclipse when the path of the moon's shadow is known.



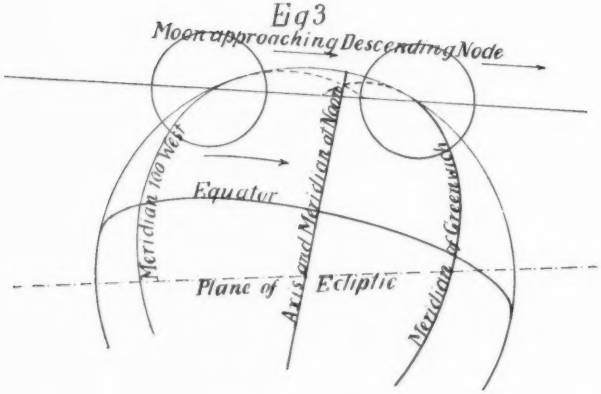


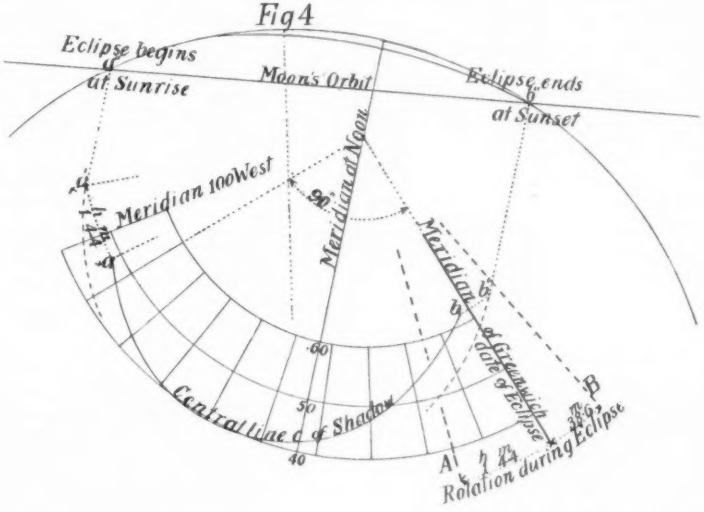
Fig. 1 represents the position of the earth at the date of the next total eclipse of the sun, January 24, 1925. The earth's heliocentric longitude will be 124° 09′. Since the scale of the drawing is unavoidably very small, the moon's orbit is scarcely visible.

At the date of the winter solstice the projection of the earth's axis on the plane of the ecliptic is directed to longitude 90° ; and since the

axis moves into parallel positions, its projection at any other date is parallel to this line. In order to obtain a projection of the earth on a plane which is perpendicular to its radius vector, that is to say as seen in the direction of the arrow, its projection (Fig. 2) on the plane of the ecliptic must first be made, where the projection of the axis forms with the radius vector an angle $a = 34° 09'$ which is equal to the corresponding angle ($124° 09'—90°$) in Fig. 1.

The moon's shadow will traverse a zone almost wholly limited by the parallels 40° and 60° in one hour and forty-three minutes. These parallels and the central line of the shadow are shown in Fig. 2.

In Fig. 3 the moon is represented approaching the descending node; but in order to examine the conditions which obtain during the eclipse more satisfactorily, that portion of the earth's surface upon which the



shadow falls is shown on an enlarged scale in Fig. 4, which includes a projection of the zone between the meridians of Greenwich and 100° West, on a plane which is perpendicular to the axis; illustrating also the earth's rotation during the eclipse. The student is reminded that, in this projection, the radius with which each parallel is described, is equal to that of the great circle multiplied by the cosine of the latitude.

The central line *a c b* is shown at the date of the eclipse, that is to say, when the shadow is crossing "the meridian at noon" at the point *c*. It is represented by a full line; and its positions at the beginning and end of the eclipse by broken lines. The meridians of Greenwich when the eclipse begins and ends are respectively at *A* and *B*; and the first and last points of the central line at *a'* and *b'*. The latter are projected on the great circle at *a"* and *b"*. The eclipse begins at sunrise at *a"*;

and ends at sunset at b''; and the line joining these points also represents that part of the orbit which the moon traverses during the eclipse. The shadow from a to c falls upon the earth during its rotation of $1^h\ 04^m.4$; and that from c to b during the rotation of $38^m.6$.

THE EYE OF MARS.

By G. H. HAMILTON.

It is an interesting fact that on the day of opposition the "Eye of Mars" looked directly down on those regions of the earth where the most intensive study of the ruddy planet was in progress. This indeed was about as far as Mars was able to get in signalling. In spite of this fact, I have not chosen my drawing for this article from those made on August 23, but have taken one made on August 26, since it shows the same detail as that with the *Solis Lacus* central and also shows interesting marknigs in *Aurorae Sinus* (Plate XXIV).

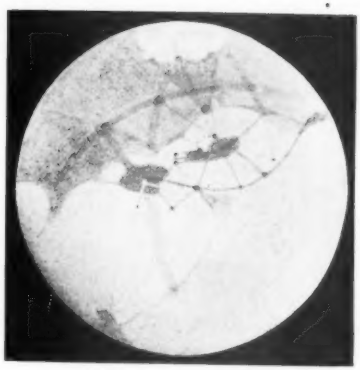
It is fortunate that the "Eye" is mostly desert, since it is to this fact, seemingly, that we owe our good view of this region and its surroundings: for it has enabled us to observe the surface detail without the detrimental effect of the Martian atmospheric haze which has a great part to play in our observation of the planet. This haze, which seems to confine itself at this season to the dark areas, will probably disappear later on.

As can be seen by the drawing, *Solis Lacus* is of a very curious shape and has at least four oases upon its edge. The *Nectar* does not seem to meet the maria as is usually the case, but is an extension of the *Solis* and ends in two of the four oases. A rift cuts the *Nectar* transversely, close to these oases, and is itself crossed by a *triple Nectar* the central canal of which passes through the whole length of the *Solis* and continues on through *Thaumasia*.

Apart from the white rift south of *Aromatum* which is not so very different from usual, another has appeared extending eastward from *Thaumasia* as if to meet it—the two combined nearly separating *Aurorae Sinus* from the rest of the maria. Nearly central in this curiously formed dark area that was left could be seen a small "oasis," but not of the usual variety—for this one was white on a dark background, the negative of those heretofore observed. This "oasis" was first noted here by Professor Pickering, and we were both agreed on the two white "canals" running from it and completely cutting off the embouchure of the *Ganges*.

The *Fons Juventae* was distinctly visible with the little canal *Bactis* joining it to the maria. Another Fons, found and provisionally called by Professor Pickering the *Pseudo Fons*, with its little canal in propor-

PLATE XXIV.

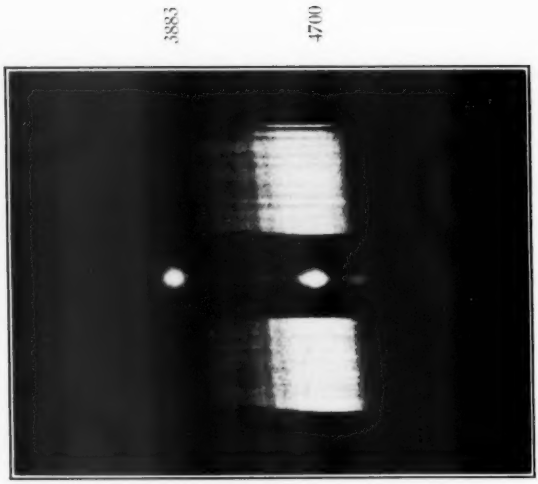


MARS, AUGUST 26, 1924

$\lambda = 67°.3$

$\odot = 244°.6$ M. D. = NOV. 28

PLATE XXV.



SPECTRUM OF FINSLER'S COMET *c* 1924,
AND ARCTURUS.

tion, left the coastline as an extension of the nearly north and south white "canal." I have not yet made out its exact location but suspect it as being on the canal *Jamuna* which is still very indistinct. This little Fons is about a third of the diameter of the *Fons Juventae*.

The persistency of the white "canals" suggests a faded surface, white by contrast, rather than cloud. If the canals are cultivated areas, could they not, when vegetation dies down, revert to the desert in the dark areas as well as in the light? It is noteworthy that a white cross similar to these canals was seen by Lowell in 1894 in the *Solis Lacus* where now two dark ones cross each other.

Mandeville, Jamaica, September 2, 1924.

SPECTRUM OF COMET FINSLER.

By J. A. PARKHURST.

The cut shows the spectrum of Finsler's comet, with the spectrum of Arcturus for comparison. It was taken through a prism of 15° angle, placed over the objective of the 6-inch Zeiss camera, the negative having a scale of 300 angstroms to one millimeter. Both objective and prism are of ultra-violet glass. The exposure was 35 minutes between $7^h\ 23^m$ and $7^h\ 58^m$ C. S. T., on Sept. 22, 1924 (Plate XXV).

The spectrum shows that nearly all the light is concentrated in the two bright bands; that at the left, (beyond the comparison spectrum) being the cyanogen band at wave-length 3883, and that at the right being the carbon monoxide band at 4700.

Another faint carbon band is shown at wave-length about 5000, and on the original negative can be seen three other bands between the two bright ones.

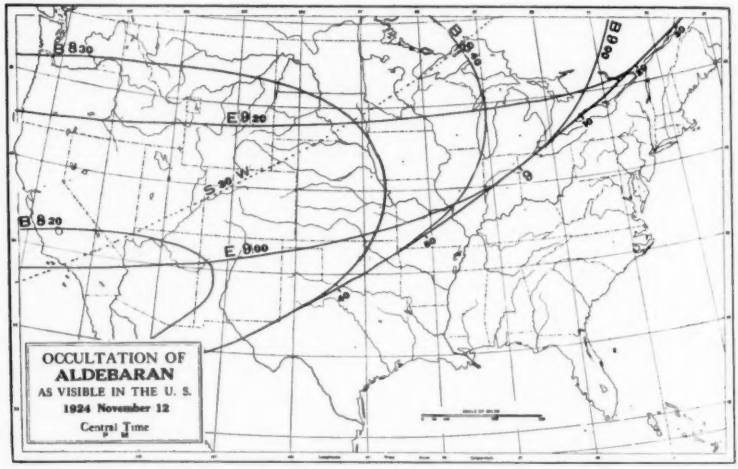
A plate taken on Sept. 23 showed no change, but was not quite as strong, as the comet was lower. The comet was just visible to the naked eye on each night.

Yerkes Observatory, Sept. 29, 1924.

OCCULTATION OF ALDEBARAN, 1924 NOVEMBER 12.

By WILLIAM F. RIGGE.

The occultation of Aldebaran of 1924 November 12 will take place at a very convenient hour of the evening, but only about half the states will get to see it, and for the western ones the moon will be very low in the sky. Then we must add to these drawbacks the fact that the moon



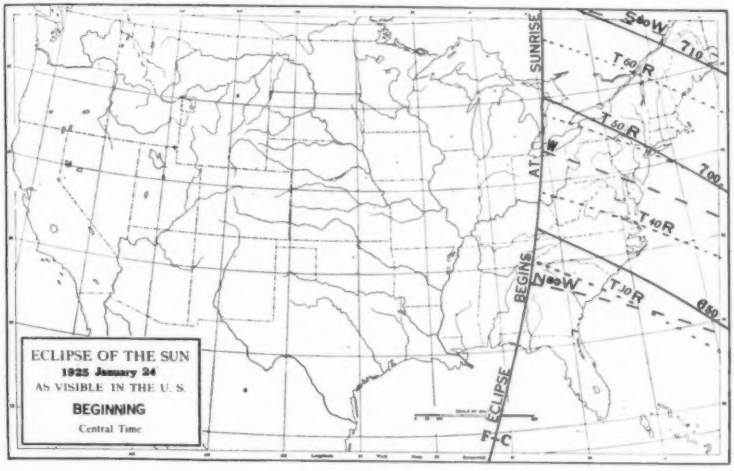
will be practically full. On the map the long curve extending from Texas to north of Maine is the Limit Line, and shows the central times of the grazing contacts. The lines marked B 8:20. . . . B 9:00 give the times of the beginning or immersion, while E 9:00 and E 9:20 give those of the end or emersion. The dotted curve S 30 W indicates the position angle at emersion, S 11 E being that on the Limit Line. A very narrow crescent along the moon's western Limb will be dark, the full phase having occurred a day and a half before.

THE TOTAL ECLIPSE OF THE SUN OF 1925 JANUARY 24.

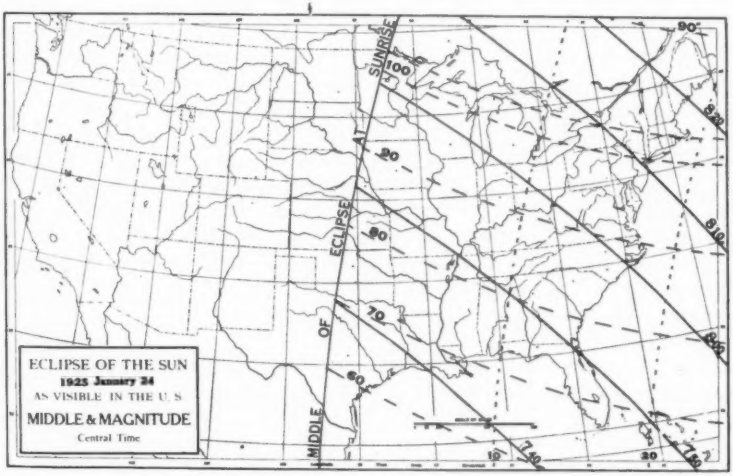
By WILLIAM F. RIGGE.

The eclipse of the sun of 1925 January 24 will be a total one over a track about a hundred miles wide extending from the northern boundary of Minnesota to Rhode Island. As a partial eclipse it will be fully

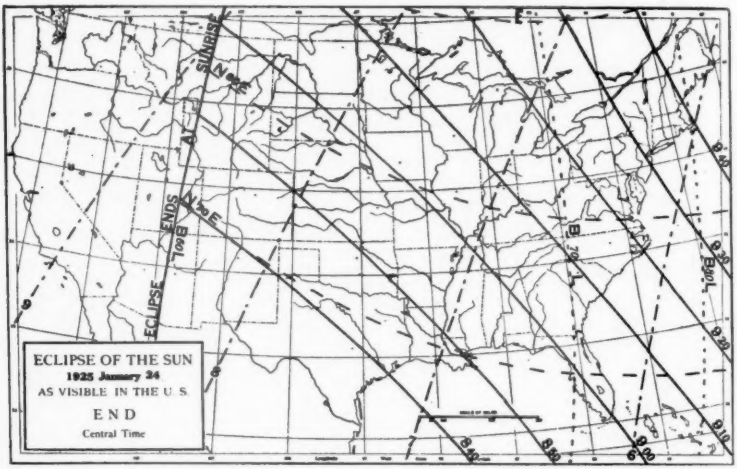
visible to the Atlantic states, not at all to the Pacific ones, and more or less to the intervening ones. On the three maps here given the full



lines show the central times for every ten minutes, the dashed lines give the position angles on Figs. 1 and 2 as measured from the cardinal points N, S, E, W, and the dotted ones give them with reference to



T, B, L, R, (top, bottom, left, right) as on a compass card. The dashed lines numbered from 70 to 100 on Fig. 2 indicate the percentage of the obscuration, while the dotted ones show the sun's altitude at the middle



of the eclipse. The dot-and-dash lines on Fig. 3 marked 6, 7, 8, 9, at the bottom, give the central times of sunrise.

ASTRONOMY OF THE TWENTIETH CENTURY.

By JOHN CANDEE DEAN.

Astronomy is the most ancient of all the sciences, and has been distinguished by its slow progress through past ages. In archaic times it was thought that the stars were fixed, at equal distance from the earth, in a dome called the firmament, as solid as the earth itself, and only a few miles above us. Nearly all that we know about ancient astronomy has been derived from the "Almagest" of Ptolemy which was written in the middle of the second century of our era. It was cherished as a sort of astronomical bible during the fourteen centuries which followed its publication, and as a consequence no progress was made in astronomy during that long period.

Extent of the Visible Universe.

In modern times, astronomy has been given great impetus, and it now ranks among the most progressive of the physical sciences. Little progress could be made in the study of the distribution of stars until a knowledge of their distances was acquired. It is only within the past 75 years that distances of even the nearest stars have been determined. The method was based on finding the stellar parallax, in which the distance of the earth from the sun was the base of the triangle. Several methods have recently been discovered for measuring the distances of remote stars, visible in the telescope. As a result of this new knowl-

edge, the depth of the stellar universe has been expanded until it is beyond human comprehension. It has been estimated that the average distance of stars, visible to the naked eye, is about 320 light years. Light has an extremely swift progressive motion of 186,000 miles a second, and to express the approximate distance in miles of the average naked-eye star, it is necessary to multiply 320 by 6 and then add twelve ciphers.

Dr. Shapley, the talented young director of the Harvard Observatory, has expanded our ideas as to the depths of the visible universe of stars, at least, to ten times what they were supposed to be a few years ago. By the study of certain short period variable stars, called Cepheids, he has been able to estimate their absolute brightness, size and distance. Cepheid variable stars are found in large numbers in globular clusters. The nearest of these clusters, Shapley found to be about 22,000 light years from us.

The best known globular cluster is that in the constellation of Hercules, which may be seen with the naked eye. Even in a small telescope this cluster is a very beautiful and interesting object. By Shapley's system, the distance of any group or cluster of stars containing Cepheids may be determined. The distance of the Magellanic Clouds is computed by Shapley to be about 210,000 light years, while a still more remote cluster known as 6822 of the New General Catalogue is estimated to be at the brain-racking distance of a million light years from us. The appliances attached to modern telescopes, such as the spectroscope, dry photo plate, photometer, interferometer, etc., have greatly assisted astronomers in wresting from Nature the new knowledge of stellar evolution.

Stellar Evolution.

The average man generally refers to evolution as Darwinism. He does not know that Darwinism pertains especially to the origin of species, and to the survival of the fittest. He revolts against biological evolution because it offends both his vanity and his religious superstitions, by teaching that his early ancestors belonged to the apes. He knows not that geology, paleontology and astronomy are evolutionary sciences. If science finally accepts the theory of relativity, which teaches that matter and energy are mutually convertable, it may find that everything existing in the universe is the result of evolution. The acceptance of this conclusion would complete the theory of science fundamentally. The doctrine of evolution even as it now stands is, no doubt, the greatest intellectual achievement in all history.

The Harvard system of classifying stars was based on their varying spectra. The sequence of stars adopted were types corresponding with the following letters, B, A, F, G, K, M, which indicate the order of successive difference in their spectra. Classification by spectra coincides with classification by temperature and other physical conditions.

Many think that the modern doctrine of evolution began with Dar-

win, but the truth is that it had been applied to astronomy by Emanuel Kant in 1755. He employed the conceptions of the Newtonian solar system to bring out what is known as the nebular hypothesis. Laplace put this hypothesis on a mathematical basis in 1796. This gave geologists a foundation for their theories and finally the way was prepared for Darwin's triumph. It is thus seen that the modern doctrine of evolution was first applied to astronomy, which was followed by the evolutionary sciences of geology, paleontology and finally by biology.

In 1895 Hertzsprung of the Potsdam Observatory discovered that stars fall into two groups, viz. large diffuse stars, and comparatively small denser stars. These stars he designated as "giants" and "dwarfs." Professor Russell while working on stellar parallaxes in 1913 made the same discovery. He announced that there are two great classes of stars. "The one of profuse brightness averaging perhaps a hundred times as bright as the sun, and varying but little in brightness from one class of spectrum to another; the other of small brightness which falls off rapidly with increasing redness." The true path of stellar evolution has been revealed by this discovery. In it we have presented the orderly sequence of stellar evolution which is the principal theme of this article.

The absolute magnitude is approximately the same for all types of giant stars, while the "dwarfs" decrease in brightness from types B to M. The separation of stars into giants and dwarfs is a matter of density. A primitive giant star is in a highly diffused state; gradually it contracts from the effect of its own gravitational pressure, resulting in an increase of temperature, due to the conversion of energy into heat. This increase of temperature does not sensibly increase its brightness because its diameter, or radiation area, decreases by contraction. The density and temperature of "giants" thus increase with their age.

The mass of giant stars determines their absolute magnitude and also their final maximum temperature; therefore stars of small mass cannot rise to very high temperatures. To attain the high temperature of B stars, they must be more than twice the mass of the sun, hence, the sun never was above the A type and perhaps never even reached that position. The masses of the great majority of stars range from that of the sun to twenty times that mass. Eddington states that the giant star Betelguese is 50 times the mass of the sun, but says, that with few exceptions they range from ½ to 5 times the sun's mass.

More is known about the properties of matter when in a perfect gaseous condition than when it is condensed; hence the problem of determining the interior condition of giant stars is easier than that of dwarf stars like the sun.

In December, 1920, Michelson, with his 20 ft. interferometer, measured for the first time in history the angular diameter of a star. Betelgeuse, a giant star, in the constellation of Orion, was selected for measurement. Gauging with the interferometer showed that it had a

disk of 1/20 of a second of arc in diameter. As a result of calculation it was found that Betelgeuse was not less than 200 million miles in diameter, which is larger than the orbit of the earth around the sun. It is a great balloon star of low density. It would take a million earths to make one sun, and ten million suns to make one Betelgeuse.

Doctor Hector Macpherson says, "The measurement within the past two years of the diameters of Betelgeuse, Antares, and Arcturus by the interferometer at Mount Wilson has removed the last lingering doubt as to the existence of giant stars and has placed beyond question the fact that the sun belongs to an inferior order of stellar bodies."

Globular Clusters and Short Period Variable Stars.

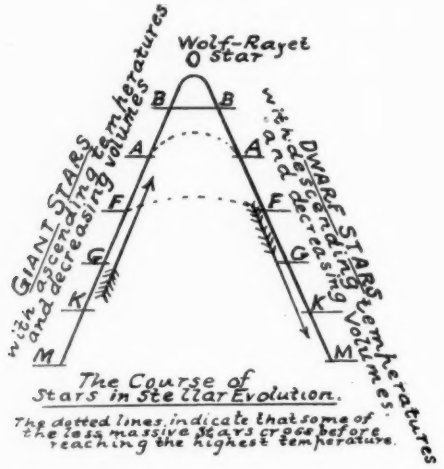
There are about seventy compact clusters of stars in the heavens called "globular" of which the cluster in Hercules is typical. Most of these clusters contain peculiar short period bright variable stars called Cepheids, which belong to the giant class. By indirect means the distance of globular clusters can be estimated with great accuracy. A determination of the luminosity periods of Cepheids and their magnitudes permit their distances to be at once deduced. When there are no Cepheid variables in a cluster, it is only necessary to determine the apparent magnitudes of the brightest stars to deduce the distance of the cluster. By these methods Shapley has obtained the distances of numerous globular clusters.

Dr. Shapley has found that the average brightness of Cepheid stars depends on their period of variation. Those with a short period of one day are about 100 times as bright as the sun. Those with a period of four days average 400 times as bright as the sun, those of ten days 1500 times as bright as the sun. Shapley found that the brightest stars of constant luminosity in globular clusters, red in color, would average about a thousand times as bright as the sun. It will thus be seen that Cepheid variables change steadily in brightness, increasing to several times their luminosity, and then fading back with great regularity, varying in different stars from a few hours to a month. Russell says that the brightest of these variables, with the unusual period of a hundred days, run up to the enormous figure of 50,000 times the sun's light. Such huge objects, however, are very rare.

Classification of Stars.

The Harvard classification of stars is based on a succession of evolutionary stages through which stars pass, indicated by the following letters, B, A, F, G, K, M. After this classification had been adopted it was discovered that there was another series of stars in an earlier stage of evolution, now called "giants," which have since been indexed with the same letters. An O type class of stars, of transcendental temperature, has been added to the top of the series as shown in the drawing. These are known as "Wolf-Rayet" stars. They have a surface temperature estimated at 23,000 degrees C. B stars are at about

20,000 degrees C., surface temperature. The sun is about 5600 degrees C., surface temperature, which puts it down in the F class, now turning gray with age. The sun is passing through its tenth stage of evolution, and has but three more stages to pass, when it will change to a dark red star and then to dead black invisibility.



The Course of Stars in Stellar Evolution.

The dotted lines indicate that some of the less massive stars cross before reaching the highest temperature.

An "easy method" for distinguishing dwarf stars from giant stars is described by Eddington. This method is really a way for finding the value of gravitation at the surface of a star. The lower density of the surface of different stars should strengthen the "enhanced" lines due to ionized atoms, compared with the arc lines due to neutral atoms. This distinguishes quite easily the ascending and descending series. To a limited extent it also distinguishes the larger from smaller stars within the same series.

The interior temperature of a star is surprising. Eddington says, "It is from two to twenty million degrees C., at the center. Do not imagine that this degree of heat is so vast that ordinary conceptions of temperature have broken down. These temperatures are to be taken quite literally. Temperature is a mode of describing the speed of motion of the ultimate particles of matter."

The heat of the interior of stars is sufficient to dissociate all chemical combinations, consequently solar matter is in its monatomic, or elementary condition, and in the hottest stars much of it may be in the electronic state. Perhaps there is a critical, or maximum temperature for all matter, where the violence of the motion of clashing atoms causes them to break up into electrons. In stars of the highest temperature, this critical state has probably been reached and the greater part of their matter is in the form of electrons. When matter is in its

hottest state, it is at its lowest point in the scale of evolution, and progress depends on a fall of temperature by radiation. Lockyer's inorganic evolution, joined to the nebular hypothesis, and this to geological and biological evolution, completes the evolutionary cycle of matter in its present terrestrial stage.

Russell of Princeton, Shapley of Harvard and Eddington of Cambridge Universities, have been the most important contributors to the new evolutionary theory of stars which is being discussed in this article. Shapley tells us that the nearest systems of stars do not show that they are more advanced in evolution than the very distant stars which are 200,000 light years away, and are therefore, 200,000 years older than the nearest stars. He points out that we can, in effect, examine stars in process of evolution during a period of 200,000 years. Our knowledge of stellar evolution, in this respect, is more positive than in biological evolution, because stars can be seen in every stage of their evolutionary progress, from the youngest "giant" down to the oldest disappearing dark red, dwarf stars. The problems that arise in stellar distribution include the relative frequency of evolutionary changes.

Evolution of "Giants."

The dark diffuse nebulae are now recognized as the cause of dark places in the heavens which were formerly supposed to be open spaces showing the vacant background of the universe. The dark nebula in Orion, the "Coal Sack" in the Galaxy and the great dark rift in the Milky Way from Aquila southward through Sagittarius, are now recognized as obscuring clouds of dark nebulous matter.

It is thought that the evolutionary sequence periods of K and A stars are very long, while Shapley concludes that stars in the sun's phase are about 1800 times more numerous than the highly luminous and massive B stars, which are believed to be in an earlier stage of evolution. The fact that there are four or five times as many giant M stars as there are giant B stars indicates that few have sufficient mass to attain the highest temperature in the sequence.

In the successive changes in the sequence of *dwarf* stars, they begin with B, which are sun stars at the highest point of their temperature and luminosity. They are of a brilliant blue white color. A stars are white. F stars are yellow white, to near pure white. G stars are yellow to yellowish white. K stars are orange. M stars are orange red, to pure orange. It is thus seen that the recognized classification of stars by their spectra is also a classification according to color.

The long period giant variables of class M have diameters of 100 to 200 times that of the sun. Twelfth magnitude stars average a distance of about 1000 light years. Five-sixths of the stars visible to the naked eye are almost 1000 light years distant.

Some Cepheid variables are visible to the naked eye. Russell found that such stars, with a period of eight days, were about a thousand

times as bright as the sun. The question of the origin of the youngest giant stars is still to be solved. There are extended areas of nebulous matter in the background of the Milky Way as shown by the photographs taken by Barnard and others. The youngest giant stars have probably developed from masses of diffuse nebulous matter which have separated from larger bodies of nebulous gases. The most massive of the giants are thought to be evolved from nebulous clouds having an unusually large amount of hydrogen in their composition.

It is now generally thought that all diffuse nebulae are dark; those which are luminous are not self luminous, but shine from the reflected light of bright stars within the nebulae or from stars which surround them. The typical spectra of diffuse nebulae show hydrogen and helium, and a third element unknown to the earth, called "nebulium." The great nebula of Orion is immense in size. It shows movements in different directions in its various parts. In some places a radial velocity approaching six miles a second is indicated. There are also movements of stars, in which they take the same speed and direction of motion as the nebulous matter in which they are immersed.

The Milky Way.

Recent study of evolution in the Milky Way involves the movements of open and globular star clusters. There is a constant expansion of our conceptions respecting the immensity of the Milky Way. All open clusters are found contiguous to it, and hundreds of such clusters are found within its borders. The globular clusters are a part of the Milky Way system, and the distance of the most remote clusters, indicates that they are within the limits of the Galaxy. The clusters do not appear to be uniformly distributed on both sides of the Milky Way, which is regarded as proof that our solar system is at a vast distance from the center of the Milky Way system; perhaps 230,000 light years from it.

Dr. Shapley presents a novel theory of development in the Milky Way. He suggests that the brighter stars near the sun may be, to a large extent, members of a local system which is embedded in and moving through the general star field of the Milky Way. He thinks that star clusters, and especially globular clusters are swinging back and forth through the Galaxy, and during each passage losing more or less of their stars.

The velocities of movement of globular clusters, so far as known, are high. The clusters are like huge pendulums swinging back and forth through the Milky Way with an oscillating period of perhaps hundreds of million years. They swing out into the field of scattered stars, then back through the Galaxy. In his address before the British Astronomical Association, Dr. Shapley said: "From the present evidence as to mass, velocity, and distribution, there can be little doubt but that the known globular clusters pass to and fro through the star fields of the galactic system, notwithstanding their observed avoid-

ance, apparent or temporary, at the present time. Every passage must reduce the velocity and alter the form. The hypothesis that these globular clusters are being diverted by degrees into galactic regions, and gradually robbed of their stars, is upheld by observation and is not opposed by present dynamical theory. Although we see few intermediates between the globular and the more typical open clusters, many of the characteristics of the open groups strongly support the suggestion that they are the remnants of globular clusters or of other systems that have been assimilated by the incomparably more massive galactic assemblage. Nearly a dozen 'moving' clusters, comprising thousands of members, are recognized among the stars within seven hundred light-years of the sun."

Planetesimal Hypothesis.

Since the beginning of the twentieth century, the Laplacian Ring Hypothesis of the solar system, which stood for more than a century, has been overthrown and been replaced by the Planetesimal Hypothesis. It could not stand recent physical and mathematical tests. It was shown that eccentric orbits could not be expcted, on a ring theory basis. The orbits of the asteroids contradicted the ring theory. The rings could not have been left off the central mass as supposed. A ring could not condense into a planet. The retrograde motion of certain satellites of Jupiter and Saturn contradicts it, and other important objections to the hypothesis of Laplace have been found.

The Planetesimal Hypothesis of Chamberlain and Moulton of Chicago is briefly as follows: At first the sun had no planets. All stars are in motion, and the sun's velocity through space is thirteen miles a second. By accident, billions of years ago, another star passed very near to the sun. As the approaching star came opposite the sun its gravitational attraction raised enormously high tides in the fluid and gaseous matter of the sun. If the visiting star had passed at a distance of three of four diameters of the sun, the waves would have sunk back, and no permanent change would have occurred. But as the star passed nearer than that, a disruption occurred from waves drawn up thousands of miles high.

It is hard to explain the details of the cause, but owing to differential attraction of the two bodies this disruption would shoot out two arms from the sun, one toward the passing star, the other from the opposite side of the sun, while the passing star would pull them sidewise sufficiently to set the arms to rotating around the sun. After this great catastrophe, the matter in the arms would settle down to orderly rotation, and the larger nuclei would gradually attract the smaller fragments to them, and in that way planets in globular form were evolved, and the spaces between the planets were cleared of the smaller nuclei. Russell estimates that the time required to bring the planets to near their circular orbits was probably several billion years. The mathematical theory of the Planetesimal Hypothesis has recently been

satisfactorily worked out by the British mathematical astronomers, Jeffreys and Jeans. It may now be said that within the first quarter of the twentieth century, a greater knowledge has been acquired of the distance, size, luminosity, mass, classification, composition, velocity, variability, magnitude and distribution of stars, than had been acquired in all previous centuries.

REPORT ON MARS NO. 28.

By WILLIAM H. PICKERING.

The Axis of Mars. Seasonal Changes.

In Report No. **26** it was shown that the location of the axis of Mars as given at present in the *Nautical Almanac* and *American Ephemeris* appeared to be in error by nearly 3°. This necessarily introduces a very considerable error into all determinations of latitude and longitude upon the planet. The determination there made was based on sixteen observations of the latitude of each of thirteen different points, 208 observations in all. These observations were all made by means of drawings, a method which proves to be the most accurate and satisfactory for locating points in latitude upon the planet. The drawings were so selected that four should be distributed near each Martian equinox, and eight near the summer solstice. No drawings near the winter solstice were available. As a result of this investigation it was found that the accepted azimuth of the polar axis of the planet with regard to the pole of its orbit was in error by the constant C equal to —2°.95, and its inclination by D equal to —0°.26.

These observations have since been revised, certain drawings being replaced by others which were found to be better adapted to the purpose. This was mainly because it was evident on consideration that for the planetocentric right ascension of the earth, $A_{\oplus}$, we should substitute what we may call the planetocentric right ascension of the point observed, as measured in the plane of the planet's equator, from its vernal equinox. This quantity we have called A. Six drawings previously used were replaced by others, several were remeasured, and in several cases the best drawing of an evening was substituted for the mean of two. Indeed, in the case of only four of the thirteen stations were no changes made. The changes produced in the two constants C and D by this revision proved, as was to be expected, extremely small, but the method is now believed to be theoretically correct. We may express A in terms of known quantities as follows:

$$A = A_{\oplus} + \omega - L$$

where $A_{\oplus}$ is given in the *Ephemeris*, ω is the longitude of the central

meridian of the planet at the time that the observation was made, and L the longitude of the point as computed by the *Ephemeris*. Then by Report No. **26** we have, simply changing $A_{\oplus}$ to A, the corrected latitude of the point

$$B' = B - C \cos A - D \sin A.$$

In the course of the revision it was decided to omit the observed latitude of Solis when located near the summer solstice of the planet. The reason for this was that Solis is situated so far south of the equator that at the average of these observations it was located within one-quarter of the radius of the limb. At that distance not only are the degrees of latitude very much fore-shortened, but, what is worse, the marking is liable to be partially concealed by limb fog, very prevalent in the south at that season, their winter, and making observation difficult. The general effect of such fog would be, by concealing the further portions, to make the marking appear nearer the equator than is really the case, and so we find it to be by the table.

In the preparation of Table I, used in the course of the revision, we took the constant C equal to $-2°.9$, and D equal to $-0°.4$, instead of the values given at the end of the first paragraph. The last line of the table, which gives a further approximation, shows that neither of these figures was quite large enough, but the change made in the second constant was evidently an improvement. The difference between the latitudes at the vernal and at the autumnal equinoxes divided by two, with the proper sign attached, gives the latitude at the vernal equinox minus the mean. These numbers are entered in the third column of the table. The latitude at the summer solstice minus the mean latitude at the two equinoxes is entered in the fifth. The fourth and sixth columns give the deviations from the means of the third and fifth. The derived latitudes and approximate longitudes are added in the last two columns. A minus sign in the third and fifth columns indicates that at the vernal equinox and summer solstice the point appears to be south of its mean position. If we reverse all the signs in the third column, the results will give the location of the points at the autumnal equinox relatively to their mean positions.

The deviations given in the fourth column seem to imply that in addition to the error that we have found in the location of the axis, there is a systematic motion of the surface detail between the vernal and autumnal equinoxes towards the south in the longitudes centering about 90° and towards the north in those longitudes about 270°. A comparison of the fourth and sixth columns shows that while the northerly motion between the vernal equinox and summer solstice was very marked, as indicated by the changes in sign between them, after the solstice was past, the change in latitude until the autumnal equinox was reached was comparatively slight.

TABLE I.

REDUCTION OF OBSERVATIONS.

No.	Station	Vernal	Dev.	Summer	Dev.	Lat.	Long.
		°	°	°	°	°	°
8	Thymiamata S.	—2.95	—0.07	—2.33	+1.54	— 1.07	20
10	Aromatum S. p.	—2.45	—0.57	—1.71	+0.92	— 0.15	31
11	Acidalium S.	—0.69	—2.33	—0.99	+0.20	+41.69	31
12	Niliacus S.	—2.80	—0.22	—1.90	+1.11	+29.00	35
23	Solis c.	—0.65	—2.37	(+2.49)	(—3.28)	—28.26	88
41	Titanum N.	—3.80	+0.78	—1.69	+0.90	—17.75	166
50	Elysium N.	—3.19	+0.17	—2.44	+1.65	+36.34	214
52	Elysium S.	—4.50	+1.48	+1.16	—1.95	+12.58	215
63	Nepenthes m.	—3.32	+0.30	+1.15	—1.94	+11.94	272
74	Syrtis N.	—4.61	+1.59	+0.44	—1.23	+24.81	285
82	Hammonis S. p.	—5.50	+2.48	+0.12	—0.91	—12.30	319
86	Ismenius C.	—1.35	—1.67	—2.06	+1.27	+46.65	331
89	Edom S.	—3.50	+0.48	+0.78	—1.57	— 3.88	348
		—3.02	±1.12	—0.79	±1.27		

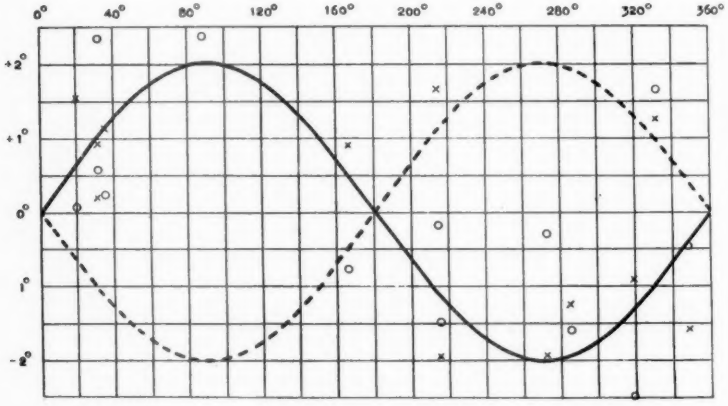


FIG. 1.

In Figure 1 we have plotted these results, reversing the signs in the fourth column, so that the ordinates represent the deviations at the autumnal equinox. These have been plotted as circles, while those deviations in the sixth column are plotted as crosses, along the Martian longitudes indicated by the abscissas. A sine curve was next drawn, and it will be seen that twenty-one observations out of the twenty-five recorded coincide with it within less than 1°.5, or 55 miles, which is as close an agreement as we could fairly expect. It will also be noted that for five out of the thirteen points selected, the two deviations are less than 1° apart, indicating a nearly stationary position of the point in latitude between the summer solstice and autumnal equinox.

If the curve represents a genuine phenomenon on the planet, then it should vibrate back and forth with the seasons, as indicated by the

dotted line, which corresponds to the vernal equinox, and should agree with the planet's winter solstice, the nodes being located near longitudes 0° and 180°. In such a case points located near these longitudes, such as Edom, —3°.50, and Titanum, —3°.80, would be best adapted for determining the position of the axis of the planet, while points located near longitudes 90° and 270°, such perhaps as Thaumasia N. and Nepenthes, would be best suited to determining the extent of the seasonal change. If a real seasonal change of this sort exists, it is probably in some way related to the pole from which the point in question receives its chief supply of water.

Returning now to the discussion of the location of the axis of Mars, for which data are given in Table I, we thought it wise to endeavor to confirm our results by securing if possible further statistics from an examination of our record books. Beginning with the apparition of 1914, which was the first one observed from the Jamaica Station, we there find that we have obtained, during the five apparitions ending with 1922, some 260 drawings which are suitable for our investigations of position. None have been accepted, save those noted in Report No. **26**, in which the diameter was less than 10″. A number of others were rejected, either on account of difficulty with the orientation, or unfavorable atmospheric conditions. From the accepted ones it was found possible to secure 536 determinations of the longitude, and 697 of the latitude of 90 different points upon the surface of the planet. On these determinations we have based two other independent investigations of the errors in the location of the axis, as given in the *Ephemeris*. In addition to the drawings used in our first investigation, many others of these same 13 points were thus secured, which were not quite so favorably placed with regard to the equinoxes and solstices, or more accurately speaking did not permit the values of A to approach so closely to the three quantities 0°, 90°, and 180°.

Our second investigation was based on the exclusive use of these additional drawings. One of the original 13 points, Niliacus, was ruled out, however, because it was necessary to have at least one good drawing giving a value for A within 45° of each of the three required values 0°, 90°, and 180°. All the other observations were treated in the manner already described in Report No. **26**. On account of the varying number of observations for the different stations however, it was now necessary to weight the different results. Since they were of different objects it was decided to weight them as the square roots of the number of observations of each. The number of observations of the different stations were as follows: Thymiamata S. 17, Aromatum S. p. 7, Acidalium S. 12, Solis c. 4, Titanum N. 14, Elysium N. 10, Elysium S. 13, Nepenthes m. 11, Syrtis N. 10, Hammonis S. p. 19, Ismenius c. 15, Edom S. 9. Total, 141. As a result, the corrections to the position of the axis in azimuth and inclination were found to be —2°.53 and —1°.05.

Still a third investigation was made of 12 other points which had not been as fully observed as the 13. These 12, and the number of observations of each are as follows: Siloe c. 5, Oxia c. 10, Margaritifer N. 16, Thaumasia p. 4, Juventae c. 11, Solis N. 4, Thaumasia S. 4, Solis f. 5, Olympia m. 5, Nilosyrtis p. 3, Nilosyrtis, junction with Syrtis 4, Aeria p. 3. Total, 74. The corrections to the *Ephemeris* determined from these points are —2°.38 and —0°.89.

The total number of observations of the 25 points here considered give us an idea of their relative visibility and suitability during that portion of the planet's year lying between the vernal and autumnal equinoxes. They range from Hammonis 35 to Nilosyrtis p. 3, and Aeria p. 3. In the majority of cases in the second and third investigations, the location of a station near either 0°, 90°, or 180° depended upon a single drawing. It was evident therefore that the results obtained from them were of distinctly inferior weight to those obtained from the first. Although the second investigation involved twice as many drawings as the third, yet since the same points were used as in the first, and it was very certain that some of these points had an appreciable proper motion of their own, over the surface of the planet, thus injuriously affecting our result, it was decided to weight these two determinations equally.

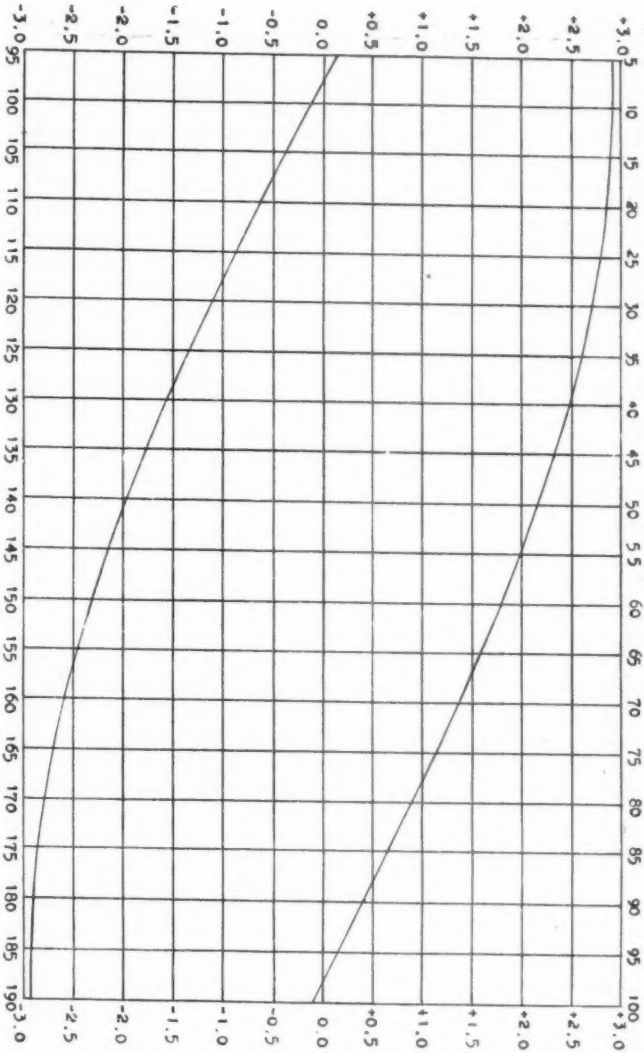
TABLE II.

CORRECTIONS TO THE EPHEMERIS.

Determination	Number	Weight	*C*	*D*
1	208	10	—3°.02	—0°.79
2	141	1	—2.53	—1.05
3	74	1	—2.38	—0.89
Weighted means			—2.92	—0.82

In Table II the results of these three determinations of the corrections to the azimuth and inclination are compared, *C* and *D* being the constants employed in the formula as already explained, for correcting the latitudes of the stations. The resulting values we see are —2°.92 and —0°.82. The resulting inclination of the planet's equator to the plane of its orbit becomes 24° 58′, lying between Struve's value, based on the motion of the orbits of the satellites 25° 13′, and the values found by Schiaparelli and Cerulli, 24° 42′ and 24° 45′ respectively, based upon the polar snows. It differs appreciably, however, from the two remaining modern values as determined by Lohse 23° 57′ and Lowell 23° 16′, which have been already mentioned in Report No. **26**. The corresponding position of the pole of the axis lies in α 315° 14′ and δ +51° 51′. Having corrected the latitudes of the various points, their corrected longitudes can now be computed by the ordinary formulae for spherical triangles.

In order to avoid all unnecessary computation, however, we may determine the correction to the *Ephemeris* result by means of the curves given in Figures 2, 3, and 4. In Figure 2 the abscissas are values of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+1.5
+1.0
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-2.5
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Fig. 2.

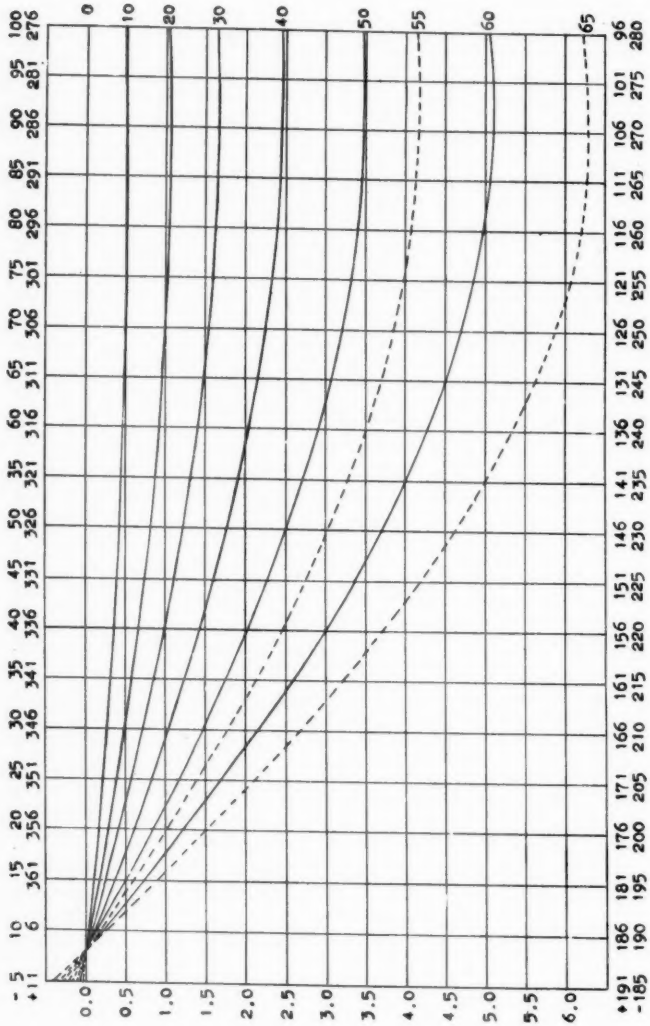


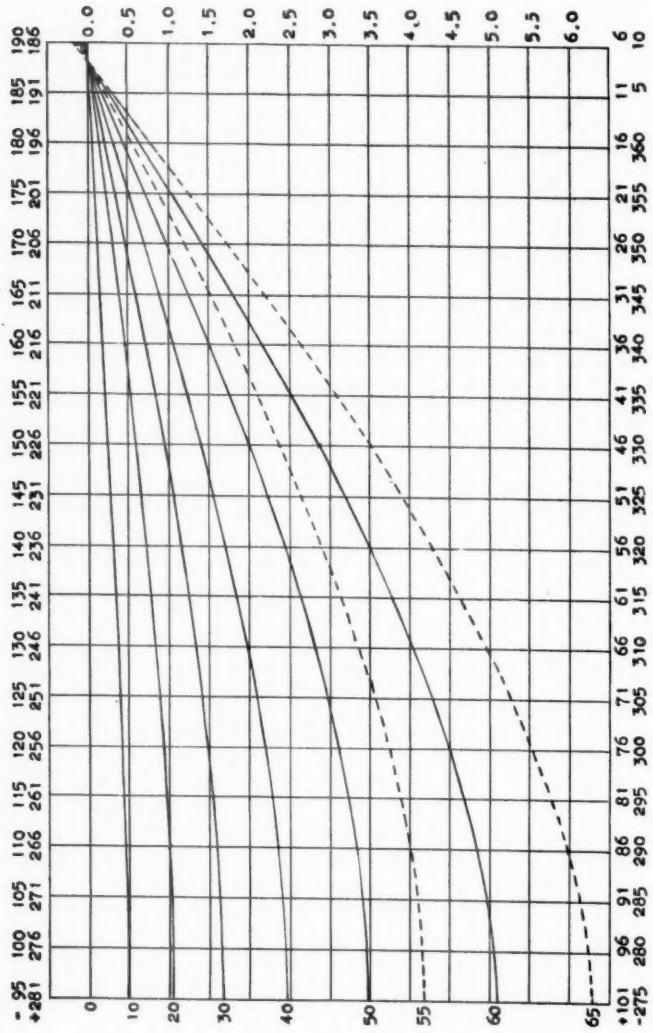
FIG. 3.

A, and the ordinates give the correction to the latitude directly. In the case of abscissas not marked on the chart, 180° must be added to them and the signs of the ordinates reversed. This curve and the two following it are reproductions on a smaller scale of the ones actually used in computing the corrections to the latitudes and longitudes of the ninety points whose positions have been determined upon the planet. They are based on the values $C = -2°.9$ and $D = -0°.4$. The values above given, $C = -2°.92$ and $D = -0°.82$, deduced from this table are perhaps rather more accurate, but not sufficiently or certainly so, to justify a recomputation of the location of the ninety points. It is believed that these curves will serve every purpose until it is possible to apply suitable corrections to the *Ephemeris*.

Figures 3 and 4 give the corrections for longitude to be applied to the *Ephemeris* results. The abscissas as before indicate values of A, and the ordinates the corrections. The curves are drawn for every 10°, and later 5° of latitude up to 65°. For higher latitudes the corrections must be computed individually. Excepting for Olympia, the large isolated snow area near the north pole, this computation was found to be necessary in the case of only one point, Boreosyrtis N. The abscissas for the northern hemisphere are given at the top of the figure, those for the southern hemisphere at the bottom. On the left of each row of figures the sign + or — indicates whether the corrections given by the ordinates should be added to or subtracted from the *Ephemeris* value. The short portion of the curve beyond the cusp has been inserted and dotted merely to make the nature of the correction clear and complete. It need not be used, but if it were, the sign of the correction would have to be reversed.

In conclusion we may give our reasons for believing that the errors in the location of the planet's axis according to the *Ephemeris* are greater than the uncertainties of modern observations justify. We believe further that unless they are corrected, these errors will lead to far greater divergencies in our observations, than would occur simply owing to errors in the observations themselves. To begin with, the *Ephemeris* is based on a method of locating the planet's axis which assumes that the polar cap extends equally far from the pole along both the eastern and western limbs. This assumption we now know to be erroneous. Therefore there is no reason to suppose that the axis should be correctly located at present.

Secondly, as we pointed out in Report No. **26**, owing to this error, chiefly in the azimuth, each one of the thirteen points there investigated apparently moved northward between the vernal and autumnal equinoxes an average distance of nearly 6°, or 218 miles, with a probable error for the series of only ±13′ measured on the surface of the planet. We have now investigated twelve other points, and of these eleven apparently moved northerly nearly as far. Only one, Solis f., appeared to move southerly, and in that case the total distance traversed was but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5.5
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0
10
20
30
40
50
55
60
65
- 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190
+281 276 271 266 261 256 251 246 241 236 231 226 221 216 211 206 201 196 191 186
+101 96 91 86 81 76 71 66 61 56 51 46 41 36 31 26 21 16 11 6
-275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 5 10

FIG 4.

1°, or 37 miles. It is not likely that the whole surface of the planet is moving northwards, and we therefore believe that this apparent motion is due to this error in the *Ephemeris,* which would fully account for it.

Oddly enough ever since the days of Schiaparelli, according to the observations of Lohse, Cerulli, Lowell, and the writer, the azimuth of the pole appears to have steadily diminished at the rate of 6′.9 per terrestrial year. Nevertheless, this apparent change cannot be real, and must be due to errors involved in the method employed in locating the axis. A third reason for doubting the accuracy of the *Ephemeris* is that Struve's location of the axis, published in 1895, and based on the motions of the orbits of the satellites, lies about half-way between that given in the *Ephemeris* and that advocated here. The change in azimuth that his position implies, —1°.5, is certainly desirable, and in the right direction, but not enough. In 1896 Marth adopted this position for his ephemeris, and it is a great pity that it was ever changed, since it was certainly much more nearly correct than the one in use at the present time.

On account of the diverse proper motions of the spots, it appears probable that at some future date, when more observations of the satellites have accumulated, Struve's method of locating the axis will be the one finally adopted. Possibly, observations made during the present apparition will permit this to be done. In the mean time accurate determinations of the location of the most clearly defined markings, by means of transits and drawings will be of the greatest value, as furnishing a permanent record of their migrations over the surface.

The next two apparitions, in 1926 and 1928, will bring the planet back nearly to the position in its orbit that it occupied in 1914, when this series of observations was begun. Should the points all move southerly in this interval to near their original positions, that fact would further emphasize our view that the accepted location of the planet's axis requires revision. It is desirable that drawings by the same observer should be employed for this purpose, and if the writer can secure a suitable telescope it will be done.

Mandeville, Jamaica, B. W. I., Sept. 1, 1924.

A DOG-DAY NIGHT.

Behind a wooded wold which walls the west,
The sunset glow has faded into night,
Above a shrouded knoll's long, treeless crest,
A cloudless moon is rising, full and white;
A breathless air oppresses vale and hill,
And sultry silence slumbers o'er the lea,
Unseen, is heard a purling meadow rill,
And crickets chant their dreamy monody.

—Charles Nevers Holmes.

41 Arlington Street, Newton, Mass.

THIRTY-SECOND MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

(Continued from page 461.)

ABSTRACTS OF PAPERS

CHARTS OF STELLAR SPECTRA MADE WITH THE MICROPHOTOMETER.

By W. S. Adams, P. W. Merrill, A. H. Joy.

Curves of stellar spectra have recently been made with the registering microphotometer of the Mount Wilson Observatory which are especially well adapted for showing the relative intensities of lines and changes of type in variable stars. In most cases the original negative has been used, but when the stellar spectrum was very narrow, use was made of an enlarged copy.

The characteristics of the intensity-curves of various spectra made in this way were shown in accompanying lantern slides. Among these are giant and dwarf stars of several different spectral types in the region λ4070 to λ4530, and of lines used in determinations of absolute magnitude and spectroscopic parallax. The enhanced lines in the spectra of type F and the low-temperature iron lines in those of type M are of especial interest.

A chart of the spectrum of HD 50138, under investigation by Merrill, shows the variation of the relative intensities of the components of bright Hβ. Changes in the spectrum of o Ceti at different phases of light are exhibited by curves of a portion of the spectrum which includes the titanium oxide bands.

NOTE ON THE EXTENSION OF BURNHAM'S GENERAL CATALOGUE OF DOUBLE STARS.

By R. G. Aitken.

The note states that the card catalogue has been brought up to date and that preparation of printer's copy is about to be undertaken. Problems relating to the form and content of the printed volume were discussed.

SOLAR MOTION DERIVED FROM THE PROPER MOTIONS OF TENTH MAGNITUDE STARS.

By Harold L. Alden and P. van de Kamp.

Relative proper motions in both right ascension and declination have been measured on plates taken with the McCormick refractor for 321 Boss stars in 287 different regions well distributed over the sky north

of declination —30°. The average number of comparison stars per region is 6.6, the mean interval between pairs of plates 6.4 years, and the average number of plates per region 4.5. The scale of the plates is 1 mm = 20″.76 so that the average probable error of a relative proper motion is of the order of ±0″.004 in each coördinate. The mean photovisual magnitude of the comparison stars is 10.14.

Considering the difference between the relative and absolute proper motions of the Boss star—in the sense, catalogue minus relative—as the mean proper motion of the comparison stars on the system of the catalogue, the solar motion and precession corrections have been derived for two fundamental systems, the *Preliminary General Catalogue* of Boss and the 1925 *American Ephemeris*. If Δk represents all the constant corrections to μ_α, Δn the correction to the corresponding precession term, and X, Y, Z the equatorial rectangular components of the sun's motion, the following values of these quantities have been derived from a least-squares solution of 64 groups into which the 287 regions were combined.

	From McCormick Proper Motions.		From 942 Proper Motions in R. A.
	Boss P. G. C.	1925 Ephemeris	Boss P. G. C.
Δk	+0″.0018 ± 9	—0″.0119 ± 9	+0″.0014 ± 7
Δn	+0.0015 12	+0.0058 12	+0.0029 25
X	+0.0039 14	+0.0017 14	+0.0002 16
Y	—0.0138 11	—0.0160 11	—0.0136 10
Z	+0.0137 10	+0.0053 10	
A	285°.8 ± 5°.3	276°.1 ± 5°.3	270°.7 ± 6°.6
D	43.6 5.2	18.3 5.2	
M	0″.0198 ± 11	0″.0170 ± 11	
$M \cos D$	0.0144 11	0.0161 11	0″.0136 ± 10

The probable errors are in units of the fourth decimal place unless otherwise indicated.

The secular parallax, M, corresponds to galactic latitude 45°, a factor having been introduced into the coefficients of the components of velocity to allow for the dependence of the secular parallax on galactic latitude. This factor was determined from the data themselves and is such that the average distance of a tenth magnitude star in the plane of the Milky Way is 2.1 times that of a star of the same apparent brightness near the galactic poles.

If, as suggested by Kapteyn, the μ_δ of Boss requires a systematic correction of the form $G \cos \delta$ and it is assumed that the solar apex should be the same with respect to tenth magnitude stars as for the brighter Boss stars, the combination of the above data with those derived by Boss (*Astronomical Journal*, **26**, 112, 1910) gives the corrected declination of the apex as +25°.7 and $G = +0''.0062$.

If we assume that the solar apex should be at R. A. 270° and declination +30° and that the mean secular parallax of tenth magnitude stars is 0″.0160 the following corrections to the μ_δ of the P. G. C. result from these data.

Declination	Correction to Boss μ_δ
−20°	+0″.0030 ± 0″.0025
0	+0.0042 ± .0020
+20	+0.0074 ± .0017
+40	+0.0048 ± .0018
+65	−0.0032 ± 0.0023

In the last column of the first table are given the results derived from the relative proper motions in right ascension of 707 Boss stars obtained from the parallax solutions at the Allegheny, Sproul, Yerkes, and McCormick observatories. They are directly comparable with the results given here and, combined with them on the basis of probable error, give as the best representation of the solar motion with respect to the proper motions of tenth magnitude stars on the Boss system the values below.

Δk	+0″.0016 ± 0″.0006		
Δn	+0.0018 ± 0.0011		
X	+0.0022 ± 0.0011	Z	+0″.0137 ± 0″.0010
Y	−0.0137 ± 0.0007		
A	279°.3 ± 4°.5	D	+44°.6 ± 5°.2
$M \cos D$	0″.0139 ± 0″.0007	M	0″.0195 ± 0″.0009

The values of Z, D and M will be affected by systematic error of the Boss μ_δ. $M \cos D$ is not open to this objection and therefore provides a better value of the annual parallax of tenth magnitude stars. Assuming $D = +30°$ and a solar velocity of 21.5 km/sec., the mean parallax of stars of apparent magnitude 10.1 is 0″.0035 at galactic latitude 45°.

The declination of the apex derived from the 1925 *Ephemeris* system of proper motions agrees well with that derived by Eichelberger from the stars of the *Ephemeris*, indicating that this system is probably less subject to systematic errors in declination than the Boss system. It requires, however, larger corrections for precession and equinox.

The results for the Boss system are based on the catalogue proper motions corrected for the precession terms given in the Introduction to the *P. G. C.* and are referred to the epoch 1920.

NOTE ON THE OBSCURED AREA NEAR ρ OPHIUCHI.

By S. I. Bailey.

Vast regions in the Milky Way are more or less obscured by occulting clouds. The obscured area near ρ Ophiuchi is one of the most interesting of these. The galactic latitude of the central part is about 13°. The region of deepest obscuration has an area of only a few square degrees, but it is connected by ramifications with the great rifts near the central plane of the Milky Way.

From counts of the number of stars of various magnitudes in different catalogues, it is evident that the obscuration begins at the mean distance of stars of about the eighth magnitude, possibly five hundred light years.

From the *Henry Draper Catalogue* it appears that the spectra of the stars shown in this area are less red on the average than those in an equal unobscured area situated about two degrees from the central line of the Milky Way.

The number of stars lost to view by this obscuration is ten thousand or more to a square degree, when stars to the twentieth magnitude are considered.

In any determination of the number and distribution of the stars in our Galactic System the effect of such obscuring clouds should be given careful consideration.

ON PARALLAXES.

By Benjamin Boss.

An attempt was made to derive corrections to the trigonometric and spectroscopic parallaxes through comparison with a mean curve giving the correlation between proper motion and absolute magnitude. This curve was formed through an arrangement of the trigonometric parallaxes in order of proper motion, median parallaxes being used to derive median absolute magnitudes for visual magnitude 6.0.

Comparison with the trigonometric series gave the following corrections: +".0010 to Allegheny, +".0011 to Greenwich, +".0004 to McCormick, —".0015 to Mount Wilson, —".0075 to Sproul, —".0001 to Yerkes, and —".0231 to Dearborn. As the constant corrections seem to decrease with accumulation of material it is probable that they are fictitious, excepting the case of Sproul where a selective process has apparently introduced a real deviation from the mean results, and in the case of Dearborn.

When compared with the 1646 Mount Wilson spectroscopic parallaxes, corrections are derived for the latter system amounting to —1.5 magnitude at 0".00 proper motion, and decreasingly minus to proper motion 0".04. Then the corrections become positive until proper motion 0".16 is reached, after which they are small, though there is a systematic trend.

For the 544 spectroscopic A-type parallaxes of Mount Wilson the correction is —2.1 absolute magnitudes at 0".00 proper motion, decreasing to —0.3 magnitude at proper motion 0".06 and constant for larger values of the proper motion.

GRAVITATIONAL FORCES IN SPIRAL NEBULAE.

By Ernest W. Brown.

Numerical Analysis. An analysis is made of the radial, rotational and angular internal velocities of the spirals M 33, 81, 51, 63, 94, 101, N. G. C. 2403, measured by van Maanen. The conclusion is drawn that only along the arms are the velocities tangential to those arms, that

the angular velocities in each spiral have the same sign and diminish from the nucleus outwards, and that the radial velocities may have either sign and be of any magnitude outside of the arms.

Hypotheses. It is shown that the average angular and radial velocities at different distances can be explained on the assumption that the nebula consists of a nucleus of concentrated matter together with a widely extended distribution of low space density, in which collisions are rare. The particles or masses constituting this distribution are supposed to be describing orbits under the attraction of the matter present. To account for the arms, the further hypothesis is made that these orbits are of such a character that their envelopes are the arms of the spiral and that the latter structure shows on account of the resulting concentration of matter on the envelope.

Conclusions. The space densities of the distributed matter are of the order 10^{-15} that of the sun, and their masses, with a common parallax of 0".001, of the order 10^{8}; the masses of the nuclei are smaller, but of the same order of magnitude.

SOME MEASUREMENTS OF THE SPECTRAL COMPONENTS OF PLANETARY RADIATION.

By W. W. Coblentz and C. O. Lampland.

The object of the present communication is first to announce the results of measurements of the radiation emitted by planets and second to give an account of some preliminary attempts at separating this planetary radiation into spectral components.

By means of a series of transmission screens of water, quartz, glass, and fluorite the radiation emanating from the planets, e. g. Mars, was separated into spectral components and the radiation intensities determined in the spectral regions of 0.3μ to 1.4μ, 1.4μ to 4.1μ, 4.1μ to 8μ, 8μ to 12.5μ, and 12.5μ to 15μ.

In this manner it is possible to determine the shape of the spectral-energy curve of that part of the planetary radiation which is transmitted by our atmosphere and thereby form an estimate of the temperature of the effective radiating surface of the planet.

The results obtained verify our previous observations showing that the planetary radiation emanating from Jupiter and from Saturn and transmitted by our atmosphere is very small, while the planetary radiation from Mars and the moon is, relatively, very intense.

A comparison was made of the observed spectral radiation components of the planetary radiation from Mars and of similar data computed for a black body at various temperatures. From the data thus far obtained it is found that the calculated temperature, which a complete radiator or so-called black body would have to attain in order to emit a spectral energy distribution similar to that observed, is higher than previously calculated for Mars by other methods. This may per-

haps be owing (1) to insufficient information regarding the transmission coefficients of our atmosphere, (2) to a highly selective emission of the planet in this region of the spectrum, and (3) to a higher planetary temperature than heretofore supposed.

VELOCITY-CURVES FROM GROUPS OF LINES OF DIFFERENT CHROMOSPHERIC HEIGHTS IN THE ATMOSPHERE OF W SAGITTARII.

By R. H. Curtiss.

Studies of velocity-curves for groups of lines of different chromospheric heights observed in the spectrum of W Sagittarii reveal marked differences among these curves for the various groups studied. The range of velocity variation is less for greater chromospheric heights, and for the hydrogen lines at very great chromospheric height there appears to be some phase delay as compared with the velocity-curves derived from lines of small height. An irregularity shortly after maximum light seems to be common to the curves for lines of different chromospheric heights and also to the light-curve and the curve of variation of spectral class.

Three important sources of uncertainty are pointed out affecting the interpretation of velocity measures of Cepheid stars with single-prism dispersion. In the first place all of the measured features are groups of lines in which a "high line" can seldom be measured alone. Again the enhancement of a spark line at maximum light or of a sun-spot line at minimum may cause spurious displacements of a group in which such a line may be eccentrically situated. Finally in the case of any measured group or blend not exactly symmetrical the tendency toward stronger exposures at maximum light and weaker ones at minimum will lead to spurious measured velocity variations synchronous with the true light change and thus closely synchronous also with the velocity changes.

In the present study each measured feature has been analyzed on the basis of Rowland's wave-lengths and intensities of solar lines and Mitchell's chromospheric heights. A balanced atmospheric height has thus been derived, and the velocity changes for each feature have been studied separately as well as for groups.

The velocity differences observed for the several groups of lines of different chromospheric heights are considered to be due in considerable part at least to actual differences in the motion of atmospheric layers absorbing effectively at different levels above the radiating strata. Greater chromospheric height in the sun is thought to be associated in general with higher effective absorbing level in the atmospheres of W Sagittarii and other Cepheid variables. Possibly as these studies of Cepheids develop it may become feasible to determine the effective absorbing level for any given line relative to other lines by its velocity-curve.

As a probable explanation of the different motions at different levels in the atmospheres of Cepheid variables, it has occurred independently to Aldrich, Rufus, and the writer, in extension of the pulsation hypothesis, that such motions are due to pulsations from below affecting the lowest levels first and being transmitted by them with increasing modification upward from level to level to the highest layers. Such motions of pulsatory character, probably not initially simple and affected by reflection, damping, etc., may account in large measure for the velocity-curves as we observe them. Relative motions of adjacent layers, evident in the velocity-curves, may lead to stages of compression and expansion, in the radiating as well as the absorbing layers, which may account for much of the observed light variation.

PRECESSION AND SOLAR MOTION.

By W. S. Eichelberger.

The results here presented are based on the proper motions of the new catalogue, "Positions and Proper Motions of 1504 Standard Stars," to appear in the *Astronomical Papers of the American Ephemeris,* Volume X, Part I. Of the 1504 stars in this catalogue all those are excluded from this discussion whose annual proper motions are equal to or greater than 0″.2, and whose parallaxes, as given in the catalogue, are greater than 0″.1. There remain 1198 stars.

As the details of the discussion will be published elsewhere, only the results are given here. The position of the solar apex is

$$A = 265^{\circ}.2 \pm 1^{\circ}.9$$
$$D = +20^{\circ}.5 \pm 1^{\circ}.7$$

and the correction to Newcomb's value of the precessional constant, n, the annual motion of the celestial pole towards the equinox, is

$$\Delta n = +0''.0022$$

In the *Astronomical Journal,* No. 614, from a discussion of the proper motions of Boss's *Preliminary General Catalogue,* Professor Boss finds

$$\Delta n = +0''.0034$$
$$A = 270^{\circ}.5 \pm 1^{\circ}.5$$
$$D = +34^{\circ}.3 \pm 1^{\circ}.3$$

The agreement of the values of Δn and A are very satisfactory. The large difference in the values of D is not surprising, as various determinations of this quantity in the past have ranged over 30° or more.

On this subject Professor J. C. Kapteyn says in his article "On the proper motions of the faint stars and the systematic errors of the Boss fundamental system": "If the proper motions of Boss require a correction of the form $\Delta\mu = G \cos \delta$, G being an absolute constant, these

proper motions will lead to an erroneous determination of the apex. This error in the declination must be determined by comparing the result of the astronomical proper motions with that of any other method which is absolutely independent of the $\Delta\delta$. Such a method is that by means of the radial velocities." By the use of radial velocities Professor Campbell, *Lick Observatory Bulletin*, No. 196, finds

$$A = 268^{\circ}.5 \pm 2^{\circ}.0$$
$$D = +25.2 \pm 1.8$$

It is interesting to note the agreement between the results obtained in this paper dealing with naked-eye stars and those by Harold L. Alden and P. van de Kamp from tenth magnitude stars. (See a preceding abstract.)

STUDIES OF DEARBORN OBSERVATORY PARALLAXES.

By Philip Fox and Laura E. Hill.

Parallaxes have now been determined at Dearborn Observatory for 190 stars. As these stars are of the eighth magnitude or fainter, the rotating sector in general use at other observatories engaged in photographic parallax programs has not been used. Various astronomers, in comparing parallax results, have noted that the results from Dearborn Observatory have a tendency to be high. Professor Frank Schlesinger, in preparing the general catalogue of parallaxes, noted this and systematically decreased the Dearborn parallaxes, and incidentally increased the probable errors to a figure beyond that which comes out of the actual solutions.

We have made a study to see if the differences in the magnitude of the parallax star and the mean magnitude of the comparison stars bears any relation to the difference in parallaxes. Such comparisons were made for each observatory engaged in the photographic determination of trigonometric parallaxes. The differences in parallax were platted as ordinates and the differences between magnitude of the parallax star and the mean magnitude of the comparison stars used at Dearborn Observatory, as abscissae. In each case there is a very considerable scattering, and, with the exception of Greenwich, there is a decided systematic trend, showing larger differences in parallax with greater difference in magnitude, a relation which can be represented satisfactorily by a straight line. The greatest difference between the parallax star and the comparison stars of the Dearborn series, is about 1.5 magnitude. The constants of the formula, $y = a + bx$, have been determined for each series under comparison. Here x is the diameter difference in millimeters and y the correction in parallax to reduce to the sector system. A diameter difference of 0.10 mm corresponds to 1.6 magnitudes.

Observatory	*a*	*b*	Comparisons
D. — Allegheny	+0".008	—0".574	21
D. — McCormick	+0.001	—0.432	31
D. — Yerkes	—0.001	—0.585	33
D. — Sproul	+0.027	—0.534	6
D. — Mt. Wilson	+0.021	—0.445	8
D. — Greenwich	+0.002	—0.047	9
D. — All	+0.004	—0.444	

Inasmuch as this systematic difference in parallaxes of each individual comparison shows uniformity, the conclusion would probably be reached at once that it is the Dearborn series which is at fault. There are, however, certain reasons for leaving this an open question. For example, the components of Krueger 60 have very considerable difference in magnitude, yet the parallaxes as determined from the Dearborn plates are practically identical. Certain other fields where the parallaxes of two stars of different magnitude have been determined show similar results. Professor O. J. Lee, in his report on the parallaxes and proper motions of the stars in the 45°-zone of the Kapteyn systematic plan, finds no systematic difference in parallax of stars in a range from the seventh to the fourteenth magnitude. On the other hand, the sector is known to introduce some difficulties, as was noted by van Maanen who found it impracticable to use it on certain double stars because of diffraction effects introduced by the sector.

This study shows that one is not warranted in applying a uniform correction to the Dearborn parallaxes to reduce them to the system of the parallaxes obtained at the observatories where sectors are used. In the great majority of the Dearborn parallaxes there is very little difference between magnitude of the parallax stars and the mean of the comparison stars, and for these there is no systematic difference in parallax between Dearborn results and those from the other observatories. The brighter parallax stars constitute the greater part of the fields available for comparison, and it is this selective comparison, where the Dearborn parallaxes have their greatest excess values, that has lead to the erroneous conclusion that a correction must be applied to all, and still further erroneous that it is a uniform correction.

MASS OF SATURN'S SYSTEM FROM OBSERVATION IN PAIRS OF SATELLITES.

By Asaph Hall.

The plan of observing the relative positions of satellites in pairs seems to have been begun by Bessel. It was revived by Otto Struve, and followed extensively by Herman Struve.

With an equatorial the measures by pairs are more accurate than those which refer a satellite directly to the planet. But the computations for determining the corrections to the elements of the satellites' orbits are somewhat laborious and complicated when observations are taken in this way, since corrections to both orbits of a pair are involved, thus making twelve unknowns to solve for in each set of observation

equations, or eleven unknowns if Kepler's third law is supposed to hold.

After the semi-major axis of a satellite's orbit is had, the mass of the planet can be computed, the mass being obtained with more certainty when considerable distances are measured, providing these distances can be measured accurately and without systematic error.

The following tables give the results of the solutions of the observation equations with eleven unknown quantities for the oppositions of Saturn from 1909-1910 to 1915-1916.

The value of da/a is supposed constant, from one satellite orbit to another, that is, $da_1/a_1 = da_2/a_2$. After each da/a is written its probable error. The mass of the planet in terms of the sun's mass has been taken as 1/3500, or $\mu_0 = 3500$, and under the heading $d\mu$ is given the resulting correction to the assumed reciprocal of the mass. Finally, μ is the reciprocal of the mass resulting from observations.

It is thought that $\mu = 3494$ might be taken as the result of all the observations of the tables, that is, the mass of Saturn's system with respect to the sun equals 1/3494.

A number of observers have obtained $\mu = 3486$. The classical value of Bessel found with the heliometer, by referring the satellite Titan to the planet, was $\mu = 3498$.

From observations of Titan with the Yale heliometer I found $\mu = 3500$. Hermann Struve obtained $\mu = 3495$.

An inspection of the table for Titan-Rhea shows that my own habit of observing must have changed after the second opposition.

Great pains were taken to make a good determination of the value of the micrometer screw, and to avoid systematic errors. A bright field was used for all measures.

TITAN-RHEA.

	Observer	da/a		$d\mu$		μ
1909-1910	H and E	+.00108	± .00007	—11.3	± 0.7	3488.7
1910-1911	H	+.00092	.00011	— 9.7	1.2	3490.3
1911-1912	H	+.00026	.00015	— 2.7	1.6	3497.3
1913-1914	H	+.00015	.00008	— 1.6	0.8	3498.4
1914-1915	H	+.00015	.00014	— 1.6	1.5	3498.4
1915-1916	H	+.00036	.00015	— 3.8	1.6	3496.2

Arithmetical Mean, $\mu = 3494.9$
Weighted Mean, $\mu = 3493.8$
Assumed for Titan, $a = 176''.578$; for Rhea, $a = 76''.170$.

RHEA-DIONE, AND RHEA-TETHYS.

	Obsr.		da/a		$d\mu$		μ
1909-1910	H	Rhea-Dione	+.00145	± .00198	—15.2	± 20.8	3484.8
1910-1911	H	Rhea-Dione	+.00078	.00065	— 8.2	6.8	3491.8
	H	Rhea-Tethys	+.00262	.00059	—27.5	6.2	3472.5
1911-1912	H	Rhea-Dione	+.00046	.00047	— 4.8	4.9	3495.2
	B	Rhea-Tethys	+.00131	.00031	—13.8	3.3	3486.2
1912-1913	B	Rhea-Tethys	+.00065	.00022	— 6.8	2.3	3493.2
1914-1915	H	Rhea-Dione	+.00084	.00021	— 8.8	2.2	3491.2
	H	Rhea-Tethys	+.00021	.00023	— 2.2	2.4	3497.8

Weighted Mean, $\mu = 3492.2$
Assumed for Rhea, $a = 76''.170$; for Dione, $a = 54''.543$; for Tethys, $a = 42''.586$.

DIONE-TETHYS.

	Observer	da/a		$d\mu$		μ
1909-1910	H	−.00442	± .00170	+46.4	±17.8	3546.4
1910-1911	H	+.00173	.00047	−18.2	4.9	3481.8
1911-1912	B	+.00077	.00041	− 8.1	4.3	3491.9
1912-1913	B	+.00120	.00028	−12.6	2.9	3487.4
1914-1915	H	−.00009	.00029	+ 0.9	3.0	3500.9

Weighted Mean, $\mu = 3492.5$
Assumed for Dione, $a = 54''.543$, for Tethys, $a = 42''.586$.
H = Hall, observer; E, Eppes; B, Burton.

TWO LONG-PERIOD SPECTROSCOPIC BINARIES.

BY W. E. HARPER.

5 Tauri.

The first star of the two discussed is 5 Tauri or Boss 804 whose visual magnitude and type are 4.3 and G9. It was announced as a spectroscopic binary, as was also Boss 1190, by Campbell of the Lick Observatory. Observations by the author at Ottawa suggested the long nature of its period and 26 spectrograms with the single prism give the following elements. The probable error of a plate is ±0.9 km/sec.

$P = 960$ days.
$e = .397 \pm .016$
$\omega = 326°.32 \pm 2°.99$
$\gamma = +14.18$ km ± 0.11 km
$K = 8.25$ km ± 0.15 km
$T =$ J. D. 2,414,899.565 ± 5.87 days
$a \sin i = 99{,}955{,}000$ km

ζ Aurigae.

This star, Boss 1190, visual magnitude 3.9 has a composite spectrum listed as K + B. It might be described as a K5, over which is superposed one of a nearly continuous nature giving a resulting "washed-out" appearance.

The elements of the orbit from 28 plates well distributed over the period are as folows:

$P = 973$ days
$e = .411 \pm .011$
$\omega = 330°.13 \pm 2°.04$
$\gamma = +10.73$ km ± 0.21 km
$K = 23.78$ km ± 0.32 km
$T =$ J. D. 2,415,122.471 ± 4.45 days
$a \sin i = 294{,}300{,}000$ km

The mass function is 1.03 times the sun, giving on probable assumptions quite a massive system. While the ordinary appearance of the spectrum is of the "washed-out" character, yet one plate, when the star was nearest the sun, is decidedly different, only the true K5 spectrum being present. Slides indicating the change were shown.

SPECTROGRAMS OF SKY POLARIZATION.

By Edward S. King.

Spectrograms have been made in an experimental way to record photographically the polarization of the sky. The spectroscope has a "half-prism" silvered on the rear surface; the lenses are two inches in aperture and about 38 inches in focal length. In use, it is pointed directly at the sky, in different positions with respect to the sun. A double-image prism, introduced into the collimator about five inches from the slit, forms twin spectra in light of opposite polarity on the photographic plate.

My purpose it to obtain quantitative measures of sky polarization throughout the spectrum. A panchromatic emulsion is employed, which has a range from the violet to line B in the red. The optical parts of the apparatus seem free from polarizing effect, as tested by light transmitted through opal glass. A Nicol in front of the slit can be made to equalize the light, but does not give the same results as when placed at the eye end of the observing telescope. On setting the Nicol visually at the four points giving equalization, the difference of the spectra in brightness, as measured when the Nicol is over the slit, may be only 0.13 magn., as compared with 1.73 magn. when the Nicol is used at the eye end. Other means of calibration will be provided. Registraton of spectra to be compared is made with a Moll registering photometer.

It is hoped that such an instrument will help to settle some of the questions concerning polarization as related to color, under different conditions of the sky. Slides of spectra and scheme of apparatus were shown.

THE TEMPORARY STAR IN THE SPIRAL NEBULA N. G. C. 5236.

By C. O. Lampland.

The present note gives a short account of the light observations of the temporary star in the great spiral nebula in Centaurus, N. G. C. 5236. The star was discovered on photographs taken with the 40-inch Lowell reflector, on May 5, 1923. While the region was accessible, observations of the star were made every clear night, both photographically and visually. Harvard Standard Regions were photographed for magnitude determinations. The summer rainy season and the nearness of the region to the sun cut short the observations in July. A preliminary light-curve of the star is shown herewith extending from May 5 to July 1, 1923. In this interval the star decreased in brightness from about magnitude 14 to magnitude 15.7. Exposures on the nebula were made again the present year, but the star was not visible on photographs of long exposure.

At the time of discovery it was hoped that the star had been caught at a favorable phase in its development, so that it would be possible to determine if the light changes are like or similar to the usual course of light changes observed in the case of galactic novae. If the rapid rise to maximum light characteristic of galactic novae also occurs for temporary stars in spirals the present star had evidently passed its maximum brightness. It will be seen that the rate of decline of the brightness of the star is comparable with some of the novae, though not nearly so marked as for such stars as Nova Persei 1901, and Nova Aquilae 1918. Suitable spectrum observations would of course directly decide the question of the nature of these stars, but such data are not readily obtained. Good light-curves will be helpful, and should be rather convincing as regards similarity in nature with the galactic novae if the observations show the sharp ascending branch to maximum. But many astronomers are probably not inclined to question the view that the temporary stars in spirals are identical in nature with the galactic novae. The assumption that these stars are distant novae seems a plausible one. The usefulness of the observational material pertaining to them is apparent in its bearing on the constitution and distance of the spirals, if further work strengthens the view or brings decisive evidence that the stars in question are true novae. More than a score of these stars have now been discovered but any definite knowledge concerning them in the way of light-curves and spectrum observations is meagre. It is therefore desirable to fill these gaps, and there seems to be no other method known at present than to undertake more systematic observations of a number of spirals. Doubtless the most promising field is intensive work on the Andromeda nebula, the greatest among the numerous spiral family, in which temporary stars frequently make their appearance.

PROPER MOTIONS AND PARALLAXES OF 1041 STARS IN SELECTED AREAS 20 TO 43 INCLUSIVE.

By Oliver J. Lee.

Four hundred plates exactly, with one exposure each, have been taken with the 40-inch refractor of the Yerkes Observatory (scale 10″.67 to the mm) in this campaign. The telescope has been in use for this purpose 343 hours or 0.295 hours per star. Only 310 plates were suitable and were measured; this is less than 13 images for each star. The 24 areas aggregate less than 9 square degrees in the sky.

After rejecting all stars on the plates which were not suitable for use, the rest were measured and reduced. The plate was measured twice in each position in quick succession and if a difference exceeded 0.0062 mm, a third measure was made at once. All reductions were in duplicate. The method of least-squares was uniformly used in the reductions. Not a single star has been omitted, and the proper motions and parallaxes, large and small, positive and negative, have been includ-

ed in the discussions, except in one case where the choice is specifically defined. Two pairs of plates, in each area, having an average difference of epoch of 8.0 years, were used for proper motion in X and Y. A general solution with linear terms only gave these motions. Then a well distributed net of faint stars (12.68 in average magnitude), which showed no appreciable proper motion, were selected and used as standards in the final solutions for μ_x, μ_y, and π, in which the terms of second order were used.

Both the proper motions and the parallaxes of these comparison stars are only about half as large as the average for all the stars.

Two sets of plates, each containing four plates, in Area 39, with 91 stars, give a direct determination of the probable errors of μ_x and μ_y. The average is $\pm 0''.007$ for a complete proper motion. On the assumption that all of the 455 negative parallaxes are errors of observation from all causes inherent in plate, measure or reduction, the probable error is $0''.017$. This holds closely for each magnitude separately from 9 to 14. When the final values of the parallaxes with and without regard to sign and the proper motions are averaged of stars lying within a central circle of the plate and three tores having radii 1, 2, 3, 4, the range is $0''.0007$, $0''.0036$ and $0''.0070$ respectively. The second merely indicates that the stars in the outer tore were slightly harder to measure than the rest; the last, that the central circle always contained the A. G. and brightest star which has in the average considerable proper motion. Division of the plate area into 12 rectangles and listing of the values in each, showed no decided axis of astigmatism in the run of these values.

The average proper motions and parallaxes are exhibited in the following table, grouped according to apparent magnitude.

AVERAGE PROPER MOTIONS AND PARALLAXES GROUPED ACCORDING TO APPARENT MAGNITUDES.

Limiting Magnitudes	Average Magnitude	No. of Stars	Average μ	Average π
6.70 - 9.00	8.06	17	$0''.0350$	$+0''.0152$
9.01 - 9.50	9.31	17	.0328	.0227
9.51 - 10.00	9.76	28	.0304	.0078
10.01 - 10.50	10.33	23	.0165	.0141
10.51 - 11.00	10.79	57	.0259	.0038
11.01 - 11.50	11.26	97	.0187	.0074
11.51 - 12.00	11.79	127	.0182	.0021
12.01 - 12.50	12.29	189	.0193	.0050
12.51 - 13.00	12.70	244	.0146	.0044
13.01 - 13.50	13.24	155	.0170	.0035
13.51 - 14.72	13.82	87	.0154	.0022

Be it noted that the proper motions come to nearly a stationary point after magnitude 11.26 at a figure which is more than twice the probable error; that the average parallaxes, even in the faintest groups of stars, are positive and that the ninth line gives a parallax of $0''.0044$ for 244 stars of magnitude 12.70. Since the comparison stars have the same

mean magnitude, 12.68, this parallax should obviously be zero if one were to interpret the table in terms of magnitude error. The range in magnitude from 6.70 to 14.72 is surely large enough to show this error if it exists in these means. No contention is made that it may not inhere in individual plates or in small groups of plates. It seems to have been eliminated in the areas and in the means of all, probably because in any series the plates are scattered over many years and many conditions of observing. No reduction to absolute appears possible as yet, for the proper motions. Only seven known proper motions from observations with the meridian circle exist for all the 24 areas. Detailed comparison of the observed parallaxes, by galactic latitudes, with the mean annual parallaxes as derived from the parallactic motions given in *Publications of the Groningen Laboratory,* No. 29, 1918, gives the following means:

Magn. Group	9.0	10.0	11.0	12.0	13.0	14.0
Aver. Obs.	″0123(35)	″0100(51)	″0058(153)	″0039(315)	″0041(400)	″0007(87)
Aver. Mean	.0050	.0035	.0025	.0018	.0013	.0009
Ratio	2.46	2.86	3.32	2.38	3.15	0.78

The evidence is that large numbers of faint stars are less than half as distant as has been supposed. In a list of 54 stars having annual proper motions ≧0″.050, the three largest proper motions, 0″.212, 0″.348 and 0″.220, belong to stars of apparent magnitude 11.12, 12.37 and 12.38, their parallaxes from the solutions are +0″.063, +0″.056, +0″.026, and yet every class of magnitude from 7 to 13 is represented.

12 stars brighter than 10.0 give	$\mu = 0''.0927$	$\pi = +0''.0357$
14 stars 10.0 to 11.5 give	.0831	.0106
28 stars fainter than 11.5 give	.0796	.0055

In future work on the Selected Areas at least 30 images should be used, taken with good instruments of considerable focal length. Previous attempts in this line have resulted in giving an entirely wrong impression of the possibilities of this method, because in some cases telescopes were used which gave quite too small a scale, in other cases all the images were put on the same plate and those belonging to one epoch were exposed in a single night, and in still other cases only a total of four images was used. (See Van Rhijn's *Third Report on the Progress of the Plan of Selected Areas,* Groningen, 1923.) Obviously nothing short of magic could produce reliable parallaxes in such a case as that last named. There is no magic in this or any other method. It is a question of careful treatment of adequate material.

It takes about eight times as long at the telescope to get the parallax of a star up to the 11th magnitude by the ordinary method as it takes to get this quantity for a star up to the 14th magnitude by this method. And, for studies in stellar distribution a democratic interest in all stars within reach of our instruments will probably prove more to the purpose, even with somewhat inferior individual accuracy, than our intense cultivation of a few stars has been in the past.

THE SPECTRUM OF ζ TAURI.

By Hazel Marie Losh.

The results of this investigation are based upon the study of ninety-eight spectrograms made with the single-prism spectrograph attached to the 37½-inch reflector of the Detroit Observatory. Lines and groups of lines were isolated and studied separately. The metallic lines were found to have a smaller range than the hydrogen. On the 1923-1924 plates, the velocities from the calcium lines were less throughout the whole period than those from the hydrogen or the iron and silicon lines. An explanation of this is, that the K and H lines of calcium were blended in 1923-1924 with stationary lines of shorter wave-length, produced by calcium in space between us and the star. The helium lines behaved differently from the hydrogen or the metals. They indicated a velocity of approach at the phases at which the other elements showed a velocity of recession. Possible explanations of this were mentioned. The velocity-curve derived from the Hβ emission line was similar to that derived from the mean hydrogen-absorption lines, but of smaller range. An approximate period of fifteen years was determined from the velocities of the center of mass at the four epochs at which data were available. The intensity variations in the Hβ emission line were found to be probably identical with the long-period variation. Variations in the forms of the velocity-curves as determined by Adams formerly, and at this observatory recently, were recognized. The period of 138 days previously determined by Adams was found to be variable.

Vertical motions of the atmosphere of the star were suggested as an interpretation of the velocity variations of the different elements, during the period of 138 days. These relative motions of the different atmospheric layers may be of the same nature as the pulsation that has been assumed and probably established to explain Cepheid variation.

NOTES ON THE LUMINOSITY-CURVE.

By Willem J. Luyten.

In all the principal objections advanced against Kapteyn's luminosity-curve the central fact is that the absolutely faint stars are relatively more abundant in the immediate neighborhood of the sun than the theory would suggest. On the other hand, we have every reason to believe that the stars with absolute magnitudes betwen 0 and +7 follow Kapteyn's curve fairly well. Inasmuch as the stars in the vicinity of the sun are very few in number, the question arises how much importance we should attach to the disagreement mentioned above.

In one of the numerous recent discussions of the luminosity law, F. H. Seares has attempted a derivation of a new law which gives a

better representation of the faint stars. Although the data he used are the best at present available, the uncertainty of his auxiliary laws is so large that any conclusions based on them are precarious.

For the luminosity law ultimately derived, a form is obtained according to which the relative frequencies continue to increase at least up to $M = 14$. Fainter than this limit we know only two stars.

The trigonometric parallaxes of large-proper-motion stars show that a linear relation between M and H fits the data well except for such extreme values of H as are at present statistically unimportant. This linear relation, together with the observed frequency curve of H leads to a normal error curve for M with a maximum fainter than Kapteyn's value, which curve, however, becomes more and more uncertain as we proceed toward fainter magnitudes.

The present writer, therefore, is of the opinion that, as a matter of practical convenience, it seems preferable to hold on to Kapteyn's analytic form, and to change the constants rather than to try deriving new analytic formulae based on but two or three stars.

SPECTROGRAPHIC STUDIES OF ECLIPSING BINARIES,
With Preliminary Results on δ Librae.

By Dean B. McLaughlin.

The velocity-curves of Algol, λ Tauri, δ Librae, RZ Cassiopeiae, and 21 Cassiopeiae are being studied at Ann Arbor in order to measure the effect of rotation of the stars during eclipse. This rotation of partially eclipsed stars has, in the past, caused systematic errors of considerable magnitude in the cases of δ Librae and RZ Cassiopeiae, one of the effects being the discordance of the spectrographic and photometric times of light minimum.

Fifty-six plates of δ Librae have been taken, and from thirty, which are within eclipse, the rotation effect has been determined. The form of the observed curve differs somewhat from the theoretical. At present only upper and lower limits of the dimensions of the system, based on assumed equality of revolution and rotation periods, can be determined. They are as follows (Sun = 1):

	Upper Limit	Lower Limit
Radius of bright star	3.44	2.75
Radius of faint star	2.95	2.36
Mass of bright star	2.01	0.91
Mass of faint star	0.98	0.62
Density of bright star	0.049	0.044
Density of faint star	0.038	0.047
Radius of relative orbit	7,400,000 km	5,920,000 km

SOME PECULIARITIES IN THE SPECTRUM OF β LYRAE.

By Antonia C. Maury.

The two hundred Harvard spectrograms of β Lyrae, extending over thirty-six years, show the complex changes, due to revolution and double eclipse, repeated with great regularity in agreement with the light-curve.

The tidal fringe is seen on the violet side of the dark lines when, following primary minimum, the approaching limb of the primary emerges from eclipse. The bright bands of the B5e companion, although it is then in front, fade gradually during the eclipse, owing to the intense light of the primary cB8 star shining through from behind, and flash out on the red side of the dark lines as the receding limb passes beyond the limb of the primary. At the opposite eclipse they flash out on the blue side on coming out from occultation.

The permanent displacement toward the blue in the dark reversals of the hydrogen and helium lines of the B5e star is verified and shown to increase with wave-length for hydrogen as well as helium, varying also with the line series.

The unexplained companions of magnesium 4481 and of helium 3964 and 3889 appear, while Hγ and Hδ and 4026 are suspected of being triple in the opposed phases of maximum velocity.

NOTE ON BINARY STAR STATISTICS.

By J. H. Moore and R. G. Aitken.

A discussion of the 235 spectroscopic binary star orbits contained in the *Third Catalogue of Spectroscopic Binary Stars,* now in press, and of the 100 reliable visual binary star orbits in our complete card catalogue of the visual binary stars, confirms the correlations developed in earlier investigations and brings out clearly the contrast in masses between the giant and the dwarf systems. Selection affects the data, but the evidence from the visual binaries, so far as it goes, points to a loss of mass in the progress of a star's evolution. The spectroscopic orbits, however, do not confirm this.

ON THE PROPER MOTIONS OF STARS OF THE THIRTEENTH MAGNITUDE.

By J. H. Oort and Hannah M. Marsh.

Through the courtesy of Dr. van Maanen the proper motions of faint comparison stars in 38 parallax fields were put at our disposal. All the central stars occur in Boss's *Preliminary General Catalogue.* The following note is an attempt to gather more information about the secular parallax of these stars and the possible systematic error of Boss's proper motions in declination after the method proposed by Kapteyn.

The discussion is very preliminary as the complete program planned by van Maanen consists of some 100 fields which will be discussed by himself. As the completion of this program will require several years, it was thought useful to publish a preliminary note about the motions obtained up to date.

The plates were taken by van Maanen at the eighty-foot focus of the sixty-inch telescope during the period from 1914 to 1924. The measures and reductions were made by Mrs. Marsh, except for three fields measured by Dr. Gingrich. Two exposures had been secured at each epoch; the average interval between the early and late plates is seven years.

The average probable error of the proper motion of one star is $\pm 0''.004$ in each coördinate as derived from the differences between the two sets of exposures. The smallness of this probable error indicates that the deviations of the proper motions of the comparison stars from their mean motion are at least partly due to real motions. After a rough correction for probable error the average peculiar proper motion in right ascension comes out $\pm 0''.009$ and in declination $\pm 0''.011$ (after excluding two stars with proper motions larger than $0''.200$, out of the 292 stars available).

The average number of comparison stars is eight, having apparent magnitudes ranging from 12.0 to 13.5 approximately. In each field the average proper motions μ_α and μ_δ of the comparison stars were computed by reducing the proper motion of the central star to the value given in Boss's catalogue.

Putting

$$p = \pi_s \cos D$$
$$q' = \pi_s \sin D \cos \delta + \Delta(\delta)$$

in which π_s represents the secular parallax, D the declination of the solar apex relative to the stars considered, and $\Delta(\delta)$ the required correction to the Boss proper motions in declination, we have the following equations of condition (assuming the right ascension of the apex to be 270°):

$$p \cos \alpha = \mu_\alpha$$
$$p \sin \alpha \sin \delta + q' = -\mu_\delta$$

If we consider sufficiently narrow zones in declination q' is practically a constant; we can then solve for p and q' in each zone separately and compute π_s and $\Delta(\delta)$ for an assumed value of D. The results come out as follows:

Limits in Declination	Number of Fields	p		q'		$\Delta(\delta)$ for $D = +30°$	
0° to +20°	10	+0″.0044	±0″.0033	+0″.0123	±0″.0022	+0″.0091	±0″.0024
+20° to +40°	15	+ .0101	.0026	+ .0094	.0018	+ .0065	.0020
+40° to +60°	9	+ .0040	.0030	+ .0067	.0025	+ .0012	.0022
+60° to +83°	4	— .0001	.0039	— .0048	.0032		
Total	38	+ .0057	.0016			+ .0054	.0014

The values of $\Delta(\delta)$ in the next to the last column have been computed on the assumption that $D = +30°$ and that in each zone p equals its total average of $+0''.0057$, which corresponds to a secular parallax of $\mathbf{0''.0066}$. The average correction to the northern Boss proper motions in declination comes out $+\mathbf{0''.0054} \pm \mathbf{0''.0014}$ (p. e). Van Rhijn and van de Kamp find $+0''.0064 \cos\delta$ for the correction (*Bull. Astron. Inst. Neth.*, No. 36), corresponding to an average of $+0''.0050$.

Although the agreement about the *size* of this quantity is very satisfactory, the interpretation remains rather uncertain if we accept the possibility of a change of apex with spectrum or apparent brightness of the stars considered. If we assumed that the apex for these stars lay at $+60°$ declination instead of at $+30°$ the average correction would be brought down to zero; the secular parallax would however be increased to $0''.0114$. A change of this amount in the apex and the secular parallax seems improbable; at the same time there *are* indications of an increase of the declination of the apex for fainter stars and part of the $\Delta(\delta)$ found may be due to this increase.

THE ASTROPHYSICAL ESTIMATION OF IONIZATION POTENTIAL.

By Cecilia H. Payne.

1. The theory of ionization in stellar atmospheres, as treated by Saha, and by Fowler and Milne, has led to a satisfactory interpretation of the astrophysical behavior of spectrum lines of known series relations. The essential validity of the theory, and of the assumption of 10^{-4} atmospheres for the partial electron pressure in the reversing layer, has been indicated by the general agreement between theory and observation. As the theory may be used to predict the temperature at which a line corresponding to known critical potentials has its maximum, it may also, if its general validity is established, be used to estimate the ionization potential corresponding to a line of unknown series relations and known astrophysical behavior.

2. Such lines have been examined, and estimates of ionization potential made, by several investigators. This method of estimating ionization potential is comparable to the physical and spectroscopic methods hitherto used, and its results are in general agreement with theirs.

3. The diagram here employed for comparing the different ionization potentials was first used by M. A. Catalán. It has also been employed for neutral atoms by Saunders, and, with somewhat less material than is now presented, by the writer. The behavior of the neutral and ionized atoms in the long period is of especial interest.

4. The astrophysical ionization potentials are of interest in comparison with the hot spark investigations of Millikan, and should provide some kind of check for the high-order excitations claimed in his experiments.

RELATION OF STELLAR VARIABILITY TO LENGTH OF PERIOD AND BRIGHTNESS.

By C. D. Perrine.

Examination, for another purpose, of the data on eclipsing stars given by Miss Clerke in her *Problems in Astrophysics*, p. 302, suggested a relation between amount of variation and length of period, which was confirmed upon tabulation as shown by the following:

Periods Days	Mean P d	Δ Mag.	Number of Stars
0 to 1	0.78	0.68	4
1 to 2	1.50	0.83	3
2 to 3	2.54	1.28	5
3 to 4	3.54	1.67	7
4 to 6	5.35	1.97	6
9 and 31	20.4	2.30	2
			27

Such a relation in stars whose obscurations had appeared to be satisfactorily explained by occultations was a surprise and led to a more full examination of the Cepheids (in which I had already noted some such effect, *Ap. Jour.*, **50**, 96, 1919) and the long period variables. Investigation of some 800 stars confirms the generality of a relation between light change and length of period in all classes of variables and has shown also some kind of relationship to apparent brightness.

Selection does not appear to account for these relationships.

While the investigation is only in a preliminary stage and a number of subsidiary points are yet to be investigated the dependences upon period and brightness seem to be established and raise the suspicion that all types of variability may be due fundamentally to one cause and that a physical one. The relationships and conditions so far encountered can be satisfactorily covered by a single hypothesis, which has suggested itself, but it is desired to complete these investigations and to examine all available evidence before publishing it.

The principal conclusions which appear to be satisfactorily established are the following:

(1). The amount of variability is a function of the period—the greater changes in brightness corresponding to the longer periods. This has been found to be the case in all classes of variables, but some classes appear to show it less markedly than others. The function is not linear although both short and long period stars appear to form a connected series.

(2). The amount of variability is a function of the star's brightness. Among the long periods the brighter stars show the greater variations, which is reversed in stars of short period.

THE POSSIBLE BEARING OF THE SPIRAL NEBULAE ON STELLAR EVOLUTION.

By C. D. Perrine.

The great obstacle in determining the order of stellar evolution is that, in our limited experience, the origin for the time scale does not exist, we do not know in which direction the changes are taking place.

No sensible changes in the evolutionary sense have been observed in the spectra of the great mass of the stars. Such changes as have been observed are small and so irregular, with the possible exception of the novae, as to throw little or no light on the general question. If we can accept the results of some recent observations of the spiral nebulae and assume that they are pertinent, these bodies point to a definite course.

It has been found by several investigators that the spectral type of a number of spirals is "late"—generally G or K. This is indicated also for practically all of these objects by the long exposures which are necessary in observing them, even with our most powerful telescopes.

Seares at Mount Wilson, using color screens, has shown that the central parts of several spirals are much richer in yellow light than the outer portions and the condensations. Late spectral types for the central portions in several spirals was found earlier by Fath and more recently by Lundmark and Lindblad. These latter observers also find earlier spectral types for condensations in the arms. As the work of Fath and of Lundmark and Lindblad was with dispersion methods, we have independent confirmation of Seares' observations.

At Mount Wilson, van Maanen, from measures of condensations in a number of the larger spirals, has obtained very consistent differences of position which show outward motion.

The belief that the spirals are composed chiefly of stars rests upon the absorption spectra of these nebulae and so far no valid reason can be assigned for doubting such a constitution, as no other physical cause is known for the production of such absorption spectra. As a considerable number of the larger spirals show practically stellar points there appears to be no reason to doubt the stellar constitution of such spirals at least. The status of the structureless objects and the central masses of many spirals which show no structures as to stellar constitution may perhaps be considered to be in doubt. But no conclusive evidence is known which justifies saying that they are not composed of stars.

Now if the central regions of the spirals are of "late" type—G and K—and the outer regions and the condensations along the arms are of "early" type, outward motion leaves only a very improbable alternative to the conclusion that in such spirals at least, *the evolution is from "late" to "early" type*. And further that it is a one way course of evolution. No reverse process seems possible, with the high outward velocities which are indicated.

The alternative is that there has been no change in spectral type dur-

ing the outward journey of the stars and matter composing the arms, that they left the central mass in the same spectral condition that they now have. If this were true, evidence of such condensations and "early" type should be found in the central masses of spirals and in the structureless objects, which does not appear to be the case.

This course of evolutionary change deduced from the spirals is in agreement with the changes pursued by the novae.

Whether or not evolution of the stars of our system proceeds along lines similar to the spirals remains to be seen. The apparent similarity of matter and physical laws in all parts of the universe which have been observed lends strength to such a possibility, but it must not be overlooked that other explanations for the spectral conditions observed in the spirals may exist and until much more information on this and other points is available the present questioning is but tentative.

(To be continued.)

OBSERVATIONS OF MARS IN 1924 AT THE LOWELL OBSERVATORY.

By E. C. SLIPHER.

This brief report on the observations of Mars secured at the Lowell Observatory has been prepared in response to a request from the editor of this publication for some comments on our observations of the planet at this opposition. As the observations are still in progress any report of the results secured must necessarily be very incomplete. Only some of the most readily deduced results will be given here.

The systematic study of the planet was continued here during the opposition this year both visually and photographically, after the manner adopted at the former approaches of the planet, with the added refinements gained from the experience of observation of past oppositions.

The major portion of the observations, both visual and photographic, were executed with the twenty-four inch refractor while a few observations for color values were made with the 40-inch reflector. In the visual work and drawings a magnification of 400 was generally employed. The high scale direct photographs with the refractor were practically all made with a magnification of about 200, using yellow filters and chiefly Cramer's Isochromatic plates. All of the negatives were impressed with trails while still in the camera so that position measures could be made from them, and most of them were exposed to a light scale before development in order that photometric results could be derived from the photographs. The photographs made with the 40-inch reflector for color values of the different markings were

made with various color filters by exposing on specially sensitized emulsions.

In spite of the comparatively low southerly declination of the planet, the observing conditions, on the whole, have been quite favorable. Indeed, on account of the almost complete absence of the rainy season which normally occurs here during July, August and the early part of September, the conditions were extraordinarily good during that period because of the consequent high percentage of clear nights. For example, during the month of August, which we generally consider the poorest month of the year here from the standpoint of the number of clear nights, observations and drawings were secured on every night during the month. In fact, very few nights were lost from this cause from March 26, when the observations were begun, up to the present time, although some nights were partly cloudy and, of course, on some nights the image was unsteady. Thus the planet was under observation almost every night, and on nights of good definition the observations were continued for as much as five or six hours. About one hundred and seventy complete drawings of the planet have been made since March 26, and about one hundred and fifty photographic plates, containing from twenty to forty images, have been secured over a period of more than five months. It seems almost needless to remark that many of the "canals" have again been recorded on the photographs. The photographs also portray many interesting changes in these and also in the behavior of the larger dark markings as well as the appearance of the polar caps.

Perhaps the most remarkable fact brought out by the observations is the similarity between the changes which took place this year and those that took place in 1909. This is true of both the dark markings and the polar caps. The photographs taken at the two oppositions portray this very clearly when compared. The correspondence between the Martian seasons at the two oppositions is almost identical, the summer solstice for the southern hemisphere of Mars falling (May 13) about seventeen days later this year than it did in 1909.

From a rather cursory examination of the observations it appears that the melting of the southern polar cap this year has proceeded at the same rate as it did in 1909. Mr. Antoniadi reports from his observations this year that there has been a very marked retardation in the recession of the cap as compared with the average recession which he got from measures of various drawings of the planet dating back to 1856. He also gets a like delay in the recession of the cap this year as compared to that in 1909. In some cases he has a difference of as much as twenty degrees in the width of the cap from the mean average width for the same Martian seasonal date and in many instances as much as twelve or fifteen degrees deviation from the mean. However, the observations made here do not verify this result but indicate the cap is receding at about the mean rate. The continuous series of photographs

of the planet obtained here during the past five months furnish ample and independent record of the cap's behavior on this point and they show clearly that he has drawn the southern cap many degrees larger than it is shown on the direct photographs, which of course tend to exaggerate its size due to imperfections of seeing and to irradiation. Thus it appears that his observed retardation in the recession of the south cap which he attributes to diminution of the solar radiation may have to be explained as largely due to errors of observation. While a more exhaustive examination of the observational material might bring out some slight differences in the size of the cap on corresponding Martian seasonal dates, these differences cannot amount to more than a fractional part of the large differences he reports.

It may be well here to further emphasize the importance of the photographic record by pointing out that when they are compared with his drawings two striking facts emerge, to-wit: the greater sharpness of the photographic image and the greater brightness of the cap in the photographic image over that shown in his drawings wherein it is depicted as of only about the same brightness as the desert regions. Since the photographs are made in the visual light the same relation between the polar caps and the background of the planet should exist in the visual observations as in the photographs. Our series of photographic and visual observations are in complete agreement, and the former are a very valuable supplement to the latter. Indeed, it is important now that visual observations be supported by simultaneous photographic observations.

At the beginning of the observations this year on March 26 the southern polar cap was 80° in breadth while now it measures but a few degrees. Many dark rifts have been observed in the cap during its period of disintegration. These also correspond in time of occurrence, and position and form with the rifts observed there by Lowell and the writer at the opposition of 1909. Some of the most prominent ones can easily be identified in the drawings made by different observers in 1894 and they show them to have the same form and position. The most prominent one is that whose mean longitude is about 270°. As the border of the receding cap approaches this marking a rather conspicuous portion of the cap becomes detached from and is left widely separated from the main cap. This event occurs about one month prior to the occurrence of the summer solstice in the southern hemisphere. This detached patch lying in approximate longitude 275° was seen this year early in September as a sharply outlined, irregularly bordered, elongated, glistening patch of white. Photographs of the planet made on September 7 this year show it in the place and of the same size as do photographs of it made on August 20, 1909, the corresponding Martian seasonal dates in the two cases being June 2 and June 3, respectively. This simultaneous occurrence of this event evidences how closely the recession and behavior of the cap this year corresponds to that in 1909.

All the other peculiarities of the south cap, such as irregularities of contour, dark bays in its border, and projection portions, brighter portions and the like, seem to have presented an exact repetition of that which was observed here in 1909.

The cap at the northern pole, which has been turned away from us by many degrees, has been visible only occasionally. The variation in its visibility has been due to large and sudden fluctuations in its size. It was unusually large and conspicuous on the night of August 16 (longitude 150°) but was not so on the night previous, while on the night of the 17th it had practically disappeared. It is obvious then that the waxing cap sometimes dissipates during the Martian night. Moreover, the northern cap was much more conspicuous between longitudes 300° and 20° on August 2, when it was clearly photographed, than it appeared at the presentation of this longitude in the middle of October, although the winter season had then advanced correspondingly. As is commonly true of the waxing winter cap, the northern cap this season has been much less bright than the southern cap. It has also been quite variable in extent in different longitudes, coming down well on the visible disk in some, while showing not at all in others. It appears to avoid the regions of the planet where large dark markings occur, such as the Mare Acidalium and the Aquae Calidae. The photographs confirm these visual observations. Since the northern cap was less brilliant than the southern cap and disappeared entirely over extensive areas during the Martian night, it would seem that at this stage of its development what was visible there was chiefly cloud or haze.

As the result of color-value photographs made with the 40-inch reflector, employing color-filters transmitting various parts of the spectral range, and exposing to specially sensitized plates possessing panchromatic qualities, the southern cap was found stronger in the blue than in the red end of the spectrum, that is, it is bluish-white and not yellow as it is often described. The same investigation shows that the dark Maria are relatively brighter in the blue than in the red part of the spectrum.

Several temporary bright areas over the surface of the planet have been observed this season. The most notable one was that which was observed between the Thoth and the Syrtis Major on August 8, while on August 9 it was farther south, lying over the Libya region, south of the Thoth. It was approximately 500 miles farther southeast on the second night than on the first night, which implied a motion of about 20 miles an hour. In the observations of it on the night of August 8 it was apparent that it was developing or moving southward and towards the preceding edge of the planet, while it had disappeared by the night of the 10th of August and was not seen or photographed again. It was more conspicuous in the Martian morning of August 9 than it was in the Martian evening of the same date. The color was

whitish and it was much less bright than the southern cap but about equal to that of the northern cap. Since this bright area was observed on a region of the planet,—the Utopia and the Libya,—which is at times subject to long term brightenings, it may occur to the reader that this was the nature of the observed phenomena, but the photographs and visual observations showed nothing unusual there the night before the discovery of the spot or on the night following, when, on both dates, the background of the planet was normal.

Another temporary white spot of remarkable note was that observed on June 21-23, in longitude 113°, and latitude 20° S. near Sinus Sirenum, observed by Dr. V. M. Slipher, who conducted the observations during the writer's absence from the observatory, and which has been described by him in the *Pub. A. S. P.*, August, 1924.

An abnormal whitening of great extent was seen on September 22 in the region about the south pole in approximate longitude 200° and latitude 75°, which was not there at the previous presentation of that longitude of the disk, late in August. It covered a very large area, was irregular and indefinite in contour, and also uneven in brightness, presenting about the same appearance that one would expect from atmospheric haze or thin clouds. It produced a remarkable change in the general aspect of the planet, as is evidenced by the photographs (see Plate XXVI, Aug. 21 and Sept. 22). This white area was not recorded at the same Martian season in 1909, as shown by the photographic record made then, but a similar phenomenon did occur in 1909 about a month later in the Martian season.

On the night of August 12 a small but fairly conspicuous bright spot was seen and photographed on the sunrise margin of the planet in longitude 320° and latitude 60° S. It attracted attention chiefly because it appeared to project so prominently beyond the otherwise smooth limb of the planet. However, I am inclined to believe that this projecting of the spot above the outline of the planet was apparent rather than real and due chiefly, but perhaps not altogether, to irradiation of the bright spot. It existed on only one Martian morning. Since it did not seem to advance on the disk with rotation of the planet one is inclined to attribute it to frost which dissipated under the sun's rays.

However, a true projection was observed on the terminator of the planet on October 4 at $16^h\ 53^m$ G. M. T. It was located a few degrees north of the northern coastline of the Mare Sirenum in approximate longitude 152° and was large and conspicuous, the approximate length, north and south, being about 250 miles. For a short time after its detection it was seen to be separated from the terminator by a narrow dark margin whose width was only a fraction of a micrometer thread. Later this line of separation disappeared. The projection presented an apparently uniform height throughout its entire extent, being estimated as three-fourths of the width of the micrometer thread. Because such small bright objects always appear larger than their true size it is

PLATE XXVI.

PHOTOGRAPHS OF MARS TAKEN AT LOWELL OBSERVATORY.

POPULAR ASTRONOMY, No. 319.

OBSERVATIONS OF MARS IN 1924 AT THE LOWELL OBSERVATORY.

Notes to accompany the reproductions.

Only a few examples of the many photographs can be presented here to portray the general appearance of the planet and the changes in the markings. In a few cases comparisons are arranged depicting changes at different Martian seasons or the recurrence of the same event at the same Martian season at different oppositions.

To enable the reader to more easily comprehend the various stages of development as depicted in these reproductions, there are given, first, the date the photograph was taken; second, our calendar date that corresponds to the seasonal date in the southern hemisphere of Mars at the time of observation; third, the number of our days counted from the date of the vernal equinox of the southern hemisphere of the planet (the duration of spring there being 147 of our days). The other notes in the legend accompanying the plates should be self-explanatory.

The photographs are arranged in each Plate so that the seasonal dates advance in order down the page, the south pole being at the top. All the photographs shown here were made with the 24-inch refractor with the planetary camera magnifying about 200 times, using the same color filter and the same kind of photographic plates.

Much of what the original photographs show is lost in the processes necessary to reproducing them here but it is hoped that enough will remain to enable the reader to trace out some of the systematic seasonal changes.

PLATE XXVI.

Row No. 1.—July 16, 1924 = Martian Date April 29, 64 days after the vernal equinox. Longitude centre 150°±. Note faintness of Mare Sirenum and Mare Cimmerium.

Row No. 2.—August 21, 1924 = M. D. May 22, 100 days after the vernal equinox. Long. centre 150°±. Note that the Maria are darker than on July 16.

Row No. 3.—August 16, 1924 = M. D. May 19, 95 days after the vernal equinox. Long. centre 190°±.

Row No. 4.—September 22, 1924 = M. D. June 13, 132 days after the vernal equinox. Long. centre 200°± (left) and 215°± (right). These images are from two negatives taken about one hour apart and they both show a great whitish area which does not exist in any of the photographs above, nor in those next below.

Row No. 5.—October 15, 1909 = M. D. July 9, 172 days after the vernal equinox. Long. centre 180°±. These show the Trivium Charontis and the Cerberus to be very faint while the Mare Sirenum and the Mare Cimmerium and the markings in the south, except the "islands," are very dark. Note that there is no trace of the white area about the south pole which is portrayed in the photographs of September 22, 1924, above.

Row No. 6.—August 10, 1924 = M. D. May 15, 89 days after the vernal equinox. Long. centre 240°±.

Row No. 7.—August 12, 1924 = M. D. May 16, 91 days after the vernal equinox. Long. centre 250°±. Note the prominence of the Bay of the Cyclops and the Syrtis Minor and the "canals" between the Trivium and the Syrtis Major.

Notes to accompany the reproductions, continued.

Row No. 8.—August 3, 1924 = M. D. May 11, 82 days after the vernal equinox. Long. 308° ±. Compare with next row.

Row No. 9.—September 30, 1909 = M. D. June 29, 157 days after the vernal equinox. Note how much darker the Deucalion and the region of the planet south of the Sabaeus Sinus and the Margaritifer Sinus show here than in the photographs next above.

PLATE XXVII.

Row No. 1.—August 2, 1924 = M. D. May 10, 81 days after the vernal equinox. Long. centre 350° ±. Compare with photographs below.

Row No. 2.—September 7, 1924 = M. D. June 3, 117 days after the vernal equinox. Long. centre 0°. These show marked development of the Deucalion and the Margaritifer Sinus between August 2 and this date. Note the detached portion of the polar cap lying to the left of the main cap.

Row No. 3.—September 30, 1909 = M. D. June 29, 157 days after the vernal equinox and 11 days after the summer solstice in the southern hemisphere of Mars. Long. centre 0°. Note the great intensity of the Deucalion and the Mare Erythraeum and compare with the photographs just above which represent earlier Martian seasonal dates.

Row No. 4.—August 20, 1909, (left) and two images of September 7, 1924, (right) of nearly the same Martian longitude and of Martian seasonal dates June 2 and June 3, respectively. These show the detached portion of the south cap to be in the same place in 1924 as in 1909, and that this development took place on practically the same Martian date in both cases.

Row No. 5.—August 2, 1924 = M. D. May 10, 81 days after the vernal equinox. Long. centre 20° ±. The Margaritifer Sinus, Aurora Sinus and the whole of Mare Erythraeum are very faint.

Row No. 6.—August 31, 1924 = M. D. May 29, 110 days after the vernal equinox. Long. centre 30° ±. Note how much the above mentioned markings have darkened since August 2.

Row No. 7.—September 23, 1909 = M. D. June 25, 150 days after the vernal equinox. Long. centre 50° ±. These photographs, by Dr. Lowell, show the Mare Erythraeum as it appeared in 1909, three days after the summer solstice in the southern hemisphere of Mars.

Row Nos. 8 and 9.—August 27 and 25, 1924, respectively. These photographs show the Solis Lacus region of Mars.

PLATE XXVII.

PHOTOGRAPHS OF MARS TAKEN AT LOWELL OBSERVATORY.

POPULAR ASTRONOMY, No. 319.

likely that the actual height of the projection was less than this, rather than more, and certainly at no time did I think that it stood out farther from the terminator than would a bright micrometer thread if set tangent to the disk. The color appeared a bluish white in contrast to the yellow surface of the planet and it gave a queer appearance to the planet, shining out from the night side of Mars like a strange light. It remained visible for about fifty minutes. When looked for the next night while the planet was under observation for several hours with intervals of good definition, the projection was not certainly seen, although once I suspected that it was re-appearing, but the terminator soon seemed smooth again, consequently I concluded that nothing anomalous was there on the second night, nor was there on the next or following nights.

During the past several months of observation the dark markings of the southern hemisphere have been undergoing interesting changes. The "seas" and dark markings there have been observed to pass through about the same seasonal development that they did in 1909.

The vernal equinox for the southern hemisphere of Mars occurred on May 13 and the summer solstice on October 6. During June, July, and the early part of August, the corresponding seasonal dates in the south of Mars being April 1 to May 15, the Maria and other dark markings in that hemisphere, except the dark border about the cap and the dark rifts within, were very faint. The Mare Sirenum, Mare Cimmerium and the Mare Erythraeum were then not very different in tone from the "islands" to the south of them and the planet appeared an almost even greyish-green tint from their northern coastline to the dark border about the rapidly receding south cap. Later as the summer solstice there approached, the "seas" darkened obviously and the canals in the southern hemisphere began to appear. During August, September and the first half of October, the Martian seasonal dates there then corresponding to our May 10 to June 28, this gradual darkening of the markings in the south of Mars has been very marked and is especially well portrayed by the photographs of the different longitudes made at each monthly presentation.

Although in general the changes have been practically identical with those observed in 1909, in some instances certain details have not appeared precisely as they did at that opposition. In the region of the planet between the Elysium and the Syrtis Major, the Nepenthes-Thoth system and the markings emerging from the Syrtis Minor and the Bay of the Cyclops have appeared abnormally dark this year. Also the Cerberus and the Trivium Charontis are now darker than they were in October, 1909 (see photographs, Plates XXVI and XXVII).

The Deucalion is the only prominent marking in the southern hemisphere of the planet that has not developed with the advance of Martian summer to the intensity that it had at the time of the summer solstice in 1909 and in 1922. While this marking darkened conspicu-

ously during September this year it was still distinctly fainter on October 12 than it appears on photographs made on September 30, 1909, although the Martian seasonal dates for the two are almost the same, the latter being only a few days later seasonally.

Aside from this example of deficient darkening and the earlier mentioned cases of more than normal intensity of the markings between the Elysium and the Syrtis Major, the progress of the seasonal development of the markings over the surface of the planet this year presents a remarkable parallel to that of 1909.

Oct. 21, 1924.

RADIOMETRIC MEASUREMENTS ON MARS IN 1924.

By W. W. COBLENTZ and C. O. LAMPLAND.

Radiometric measurements on Mars at the present opposition were begun at the Lowell Observatory in June and are still in progress. This planet was the main problem in this year's radiometric program, but Venus, Jupiter, Saturn, Uranus, and the moon were also observed. Particular attention was given to the moon in connection with the Martian temperature problem. In the next number of this publication a short account will be given of the interesting results obtained on Venus.*

The present work is a continuation of the planetary radiation measurements of 1922, which were carried out in preparation for the present opposition of Mars, with the equipment suitably adapted for the problems in hand. The radiometer was used with the 40-inch Lowell reflector, with focal lengths of 220 inches and 640 inches. Several sets of thermocouples (compensated), with receivers of different sizes and mounted in vacuum receptacles and readily interchangeable at the telescope, were available for the measurements. For most of the work receivers of very small diameters were used, as with these and the long focus mirror combination it was possible in the measurements to isolate small regions on the planet's surface. But receivers sufficiently large to intercept the whole planetary disk were also used for some of the observations. By means of suitable windows for the vacuum receptacles of the thermocouples, and with transmission screens of determined spectral limits, the planetary radiation, consisting largely of wavelengths 8 to 15μ, has been successfully separated into spectral components. In this manner it is possible to determine the shape of the spectral energy curve of that part of the planetary radiation which is transmitted by our atmosphere and thereby to form an estimate of the temperature of the effective radiating surface of the planet.

*Brief notes on this subject have appeared in *Science*, Sept. 26, p. 295 and Oct. 3, p. 318, 1924.

The extensive radiometric measurements on Mars cover different parts of the surface, such as the polar and equatorial regions, the parts of the surface exposed to the morning and afternoon sun, the dark and light areas with varying amounts of insolation, etc. The long interval of the observations, further favored by an exceptionally dry season, covers various longitudes on the planet. The length of time given to the measures brought out clearly the seasonal effects due to prolonged insolation in case of the areas of the southern hemisphere. These radiometric measurements show thus far that: the equatorial regions are much warmer than the polar regions (restricted areas about the poles) which emit practically no planetary radiation; the morning side of the planet is at a lower temperature than the afternoon side which has been exposed longer to the sun's rays; the dark regions are at a higher temperature than the light ones; there has been a gradual rise in the temperature of the surface of the southern hemisphere where summer is now advancing.

An estimate of the temperature of the irradiated surface of Mars was obtained by three methods, as follows: (1) on the basis of radiation exchanges the analysis shows that the excess planetary radiation is incoming from a source at a temperature of about 15° C; (2) by direct comparison of the spectral components of the planetary radiation of Mars and the moon, temperatures were obtained ranging from 7° C for the bright regions to 22° C for the dark regions; and (3) by comparison of the observed spectral components of the planetary radiation from Mars with similar data calculated from the laws of radiation of a "black body," temperatures were obtained ranging from —15° C for the bright regions to 12° C for the dark regions. The average of all the measurements gives a black body temperature of 18° C as compared with 25° C, obtained by direct calibration against the moon. As a whole these temperature estimates are in harmony with other observations on Mars, and the measurements indicate that the temperature of the brightly illuminated surface of Mars is not unlike that of a cool bright day on this earth, with temperature ranging from 7 to 18° C, or 45° to 65° F.

In view of the prevalent idea of a very low temperature on Mars—mean values derived by calculation, involving imperfectly known factors, and furthermore, not directly comparable with limited regions such as measured in the present observations—the herein recorded temperatures may appear high. But it is relevant to emphasize the fact that the actual temperatures at different localities on the earth show wide departures from the mean value derived for the whole globe, and that the irradiated solid surface of a planet like the earth is at a higher temperature than the overlying atmosphere for which temperatures are usually recorded by the meteorologists. The surface layer of loose sand and dust is at a higher temperature than the solid rock which affords better conduction of heat, color, etc., being comparable. If the locality considered should be a desert region, with clear, calm air

the actual radiating surface would become much hotter than shown by the temperature of the air. A large proportion of the surface of Mars is evidently Saharan—dry and dusty. Except at certain seasons, in comparatively limited regions, the observed transparency of the Martian atmosphere is very pronounced as shown by the clearness with which the surface markings are seen near the edge of the planet's disk. Our observations are doubtless concerned chiefly with the radiation emitted by the solid surface. In the case of a cloud covered planet like the earth, radiation from the solid surface could not be so readiy observed, owing to obscuration by mist and cloud and the absorption of long wave energy by the water vapor of the atmosphere. But in dry clear desert regions the radiation from the earth's surface should be readily measured from space, as the planetary radiation would be transmitted freely by the atmosphere in the spectral band between 8 and 14μ.

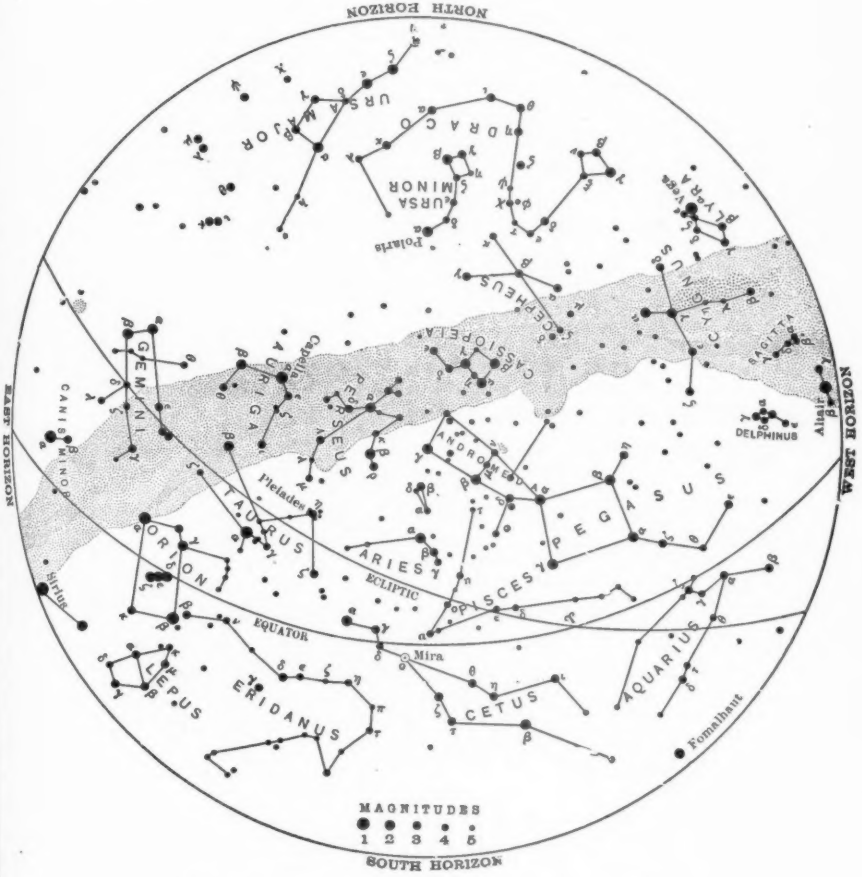
The earth according to the more recent determinations has an albedo of about .45, that is, it absorbs about 55 per cent of the incident solar radiation. Under these conditions it has a mean surface temperature of about 15° C, while the temperature of the dry solid surface rises in places to 40° C or even higher. (Perhaps it may be well to point out again that the mean temperature of 15° C is that of the air near the surface recorded by meteorologists and not the actual mean temperature of the surface of land and water.) The intensity of the solar radiation incident upon the outer atmosphere of Mars is, near perihelion, about $10 \div 19.7$ that upon the earth. But Mars reflects only 15 per cent, i. e., it absorbs more than one and one-half times as much of the incident solar energy as the earth, per unit area, with the sun near zenith. The albedo of .15 for Mars is a mean value, and many of the dark regions must reflect even less than 15 per cent. The temperature of the solid surface should therefore be expected to rise about as high as that of the earth. In fact, with much clearer skies, and with less air convection, on Mars, the temperature should in places be considerably higher than observed on the surface of the earth. There is, therefore, no need of surprise at the results recorded in this paper.

Oct. 21, 1924.

EAST HORIZON

PLANET NOTES FOR DECEMBER.

The *Sun* will move eastward from $16^h\ 29^m$ to $18^h\ 42^m$. It will move southward from —21° 49′ on December 1 to —23° 27′ on December 22, and then northward to —23° 6′ by the end of the month. It will move from Scorpio through Ophiuchus into Sagittarius.



THE CONSTELLATIONS AT 9:00 P. M. DECEMBER 1, 1924.

The phases of the *Moon* will occur as follows:

First Quarter	Dec.	3	at 3 A.M.	C.S.T.
Full Moon		11	" 1 A.M.	"
Last Quarter		19	" 4 A.M.	"
New Moon		25	" 10 P.M.	"

The moon will be nearest the earth on December 25 and farthest from the earth on December 12.

Mercury will come to a point of greatest elongation east of the sun on December 9. It will set about one hour after the sun and a little south of it. This will be a convenient season for the amateur to watch for this planet. Soon after this date the planet will begin a retrograde motion and will pass between the sun and earth on December 27.

Venus will move eastward a bit more rapidly than the sun during this month. At the end it will be two hours west of the sun. It will consequently continue to be a brilliant star during December. At the end of the month it will be a short distance north of Antares, α Scorpii.

Mars will be very favorably situated during this month. It will cross the meridian about six o'clock in the evening, and will cross the equator from south to north on December 20. It will be receding from the earth and will be decreasing in brightness.

Jupiter will be in conjunction with the sun on December 22. On this date it will be only 10′ from the apparent center of the sun. The planet will therefore pass behind the disc of the sun. This phenomenon unfortunately cannot be observed because of the brightness of the sun. Jupiter will not be visible at all during the month because of its nearness to the sun.

Saturn will be visible in the morning sky during the month. At the end it will be near the meridian at sunrise. It will be a little more than an hour east of Spica and about 30° south of Arcturus.

Uranus will be in quadrature, 90° east of the sun, on December 9. It will therefore cross the meridian between five and six o'clock in the evening.

Neptune will be in the morning sky in the eastern part of the constellation Leo.

Occultations Visible at Washington.

[*From the American Ephemeris*]

Date 1924	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle from N	EMERSION. Washington M.T.	EMERSION. Angle from N	Duration
			h m	°	h m	°	h m
Dec. 1	45 Capricorni	5.8	7 47	60	8 55	255	1 7
5	26 Ceti	6.0	4 49	66	6 7	238	1 19
	33 Ceti	6.1	10 18	41	11 32	265	1 13
7	μ Ceti	4.4	9 37	99	10 51	210	1 14
8	8 B. Tauri	6.2	3 58	85	4 56	235	0 57
11	64 Orionis	5.1	10 51	31	10 50	310	0 59
15	227 B. Cancri	6.4	8 53	70	9 46	303	0 53
15	7 Leonis	6.2	18 22	92	19 33	312	1 11
20	80 Virginis	5.6	13 28	169	13 57	233	0 29
22	γ Librae	4.0	17 34	143	18 30	263	0 56
29	42 Aquarii	5.5	6 26	70	7 33	242	1 7

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard time 6h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1924 December					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8						29 19
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	6 11	14 3	21 19	29 11		
U Cephei	0 52.4	+81 20	7.0— 9.0	1 11.8	4 1	11 12	18 23	26 11		
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	1 11	7 14	19 19	25 22		
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	1 12	10 2	18 15	27 5		
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4 4	11 0	17 21	24 18		
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	7 17	14 21	22 2	29 6		
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	2 4	10 23	19 17	28 12		
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	8 15	16 14	24 13			
RX Cassiop.	2 58 8	+67 11	8.6— 9.1	32 07.6		15 18				
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	2 6	10 21	19 11	28 1		
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	6 23	13 18	20 13	27 8		
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	3 17	11 15	19 12	27 10		
RW Tauri	3 57.8	+27 51	7.1— [11	2 18.5	8 23	17 7	25 14			
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	3 18	11 15	19 13	27 10		
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	2 23	16 4	29 9			
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	3 15	9 22	22 12	28 20		
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1		13 4		25 14		
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	6 5	12 21	19 13	26 5		
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	5 18	13 22	22 2	30 6		
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	4 19	10 19	22 20	28 21		
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	6 14	15 6	23 22			
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	9 2	19 12	29 21			
SV Gemin.	54.6	+24 28	9.8— [11	4 00.2	6 17	14 17	22 17	30 18		
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	5 9	11 2	22 14	28 7		
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	3 19	15 0	20 15	31 19		
SX Gemin.	22.0	+20 37	10.8—11.5	1 08 8	1 16	9 21	18 2	26 7		
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	3 7	10 22	18 13	26 4		
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	3 4	15 9	27 14			
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	5 2	12 6	19 10	26 14		
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	7 15	14 10	21 6	28 1		
RY Gemin.	21.7	+15 52	8.9— [10	9 07.2	5 18	15 1	24 8			
Y Can.elop.	27.6	+76 17	9.5—12	3 07.3	7 10	14 1	20 15	27 6		
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	4 3	12 12	20 22	29 8		
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	6 12	12 23	19 9	25 19		
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	6 5	13 12	20 19	28 1		
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	3 9	11 12	19 15	27 18		
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	4 1	13 12	23 0			
RX Hydrae	9 00 8	— 7 52	9.1—10.5	2 06.8	5 1	11 22	18 18	25 14		
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	3 6	9 5	21 2	27 0		
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	4 9	11 4	17 21	24 15		
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	5 13	12 23	20 9	27 19		
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	2 5	8 20	22 1	28 15		
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	5 0	13 19	22 14	31 10		
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	4 15	11 23	19 7	26 15		
Z Draconis	1 39.8	+72 49	9.9—13.6	1 08.6	3 17	10 12	17 7	24 2		
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	5 20	13 8	20 20	28 8		
RS Can. Ven	13 06.3	+36 28	7.5—12.5	4 19.1	6 8	15 23	25 13			
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	6 12	13 23	21 9	28 20		
SX Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	6 11	12 6	23 17	29 15		

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1924 December							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
δ Libræ	14 55.6	— 8 07	4.8— 6.2	2 07.9	3 1	10 1	24 0	31 0				
U Coronæ	15 14.1	+32 01	7.6— 8.7	3 10.9	1 22	8 20	22 15	29 13				
TW Draconis	15 32.4	+64 14	7.3— 8.9	2 19.4	9 9	17 19	26 5					
SS Libræ	15 43.4	—15 14	9.3—11.5	0 18.4	6 16	13 21	21 1	28 6				
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	1 19	9 3	23 20	31 4				
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	2 22	11 4	19 10	27 17				
R Aræ	31.1	—56 48	6.8— 7.9	4 10.2	3 7	12 4	21 0	29 20				
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1		10 14		31 8				
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	7 11	14 6	21 1	27 20				
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	5 13	13 22	22 7	30 17				
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	3 3	9 6	21 14	27 17				
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	5 3	11 7	23 16	29 20				
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	2 18	10 3	17 12	24 21				
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	4 18	12 22	21 3	29 7				
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	6 10	13 23	21 12	29 1				
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	6 12	14 6	22 0	29 18				
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	6 10	14 10	22 9	30 9				
WX Sagittarii	53.6	—17 24	9.2—10.8	2 03.1	9 0	17 13	26 1					
WY Sagittarii	17 54.9	—23 01	9.5—10.6	4 16.0	4 5	8 21	18 5	27 13				
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	1 12	11 21	17 1	27 9				
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	3 1	10 7	17 13	24 19				
V Serpentis	11.1	—15 34	9.5—11.1	3 10.9	7 10	14 8	21 5	28 3				
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2		13 14		28 18				
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	1 20	9 0	23 8	30 12				
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	6 9	13 11	20 14	27 17				
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	1 0	9 8	17 15	25 23				
RR Draconis	40.8	+62 34	9.3—13	2 19.9	7 2	15 14	24 2					
RS Scuti	43.7	—10 21	9.3—10.3	0 15.9	7 11	14 3	20 18	27 10				
β Lyræ	46.4	+33 15	3.4— 4.1	12 21.8	2 15	15 13	28 11					
U Scuti	18 48.9	—12 44	9.1— 9.6	0 22.9	6 2	13 17	21 9	29 0				
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	4 18	12 7	19 21	27 11				
RV Lyræ	12.5	+32 15	11. —12.8	3 14.4	3 4	10 9	24 18	31 23				
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	1 17	10 16	19 15	28 14				
U Sagittæ	14.4	+19 26	6.5— 9.0	3 09.1	4 21	11 15	25 4	31 22				
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	3 2	10 11	17 19	25 4				
TT Lyræ	24.3	+41 30	9.4—11.6	5 05.8	2 2	12 13	17 19	28 7				
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	7 1	13 13	20 2	26 15				
SY Cygni	19 42.7	+32 28	10. —12	6 00.2	1 10	13 10	19 11	31 11				
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	4 8	10 23	24 6	30 21				
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	4 19	13 22	18 12	27 15				
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	1 9	9 20	18 6	26 16				
RW Capric.	12.2	—17 59	8.8—10.6	3 09.4	1 3	7 22	21 12	28 7				
UW Cygni	19.6	+42 55	10.5—13	3 10.8	7 18	14 16	21 13	28 11				
V Vulpec	32.3	+26 15	8.2— 9.8	37 19.0								
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	3 12	13 3	22 18					
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	1 10	10 15	19 19	29 1				
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	3 9	12 9	21 9	30 8				
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	6 2	13 16	21 6	28 21				
RR Vulpec	20 50.5	+27 32	9.6—11.0	5 01.2	1 15	11 18	21 20	31 22				
RY Aquarii	21 14.8	—11 14	8.8—10.4	1 23.2	3 3	10 23	18 20	26 17				
UZ Cygni	35.2	+43 52	8.9—11.6	31 07.3		13 12						
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	1 17	11 20	22 0					
RW Lacertæ	22 40.6	+49 08	10.2—11.2	5 04.4	2 6	12 15	17 20	28 4				
VW Pegasi	51.7	+32 42	10.0—10.6	5 06.4	11 19	17 1	22 8	27 14				
Y Piscium	23 29.3	+ 7 22	9.0—12.0	3 18.4	8 11	15 23	23 12	31 1				
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	4 21	13 3	21 9	29 15				

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1924 December					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7	8 21					
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 01.7	3 22	12 2	20 5	28 9		
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	7 18	15 12	23 6	31 0		
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	2 3	16 22	31 17			
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	4 18	12 16	20 15	28 13		
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	2 1	9 20	17 16	25 11		
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	2 23		19 9			
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	6 3	14 17	23 7	31 21		
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	9 14	20 16	31 19			
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	8 17	20 8	31 23			
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	6 9	14 1	21 17	29 9		
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3	8 15	18 18	28 21			
Y Aurigæ	21.5	+42 21	8.6— 9.6	3 20.6	7 11	15 4	22 21	30 14		
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	4 18	10 7	21 8	26 21		
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	3 13	11 3	18 16	26 6		
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		18 14				
R Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	2 13	10 0	17 11	24 22		
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	7 3	15 1	22 23	30 21		
ξ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	2 15	12 19	22 22			
RU Camelop	7 10.9	+69 51	8.5— 9.8	22 06.5	2 20		25 3			
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	5 11	13 9	21 8	29 7		
V Carinae	8 26.7	—59 47	7.4— 8.1	6 16.7	5 10	12 5	18 20	25 12		
T Velorum	8 34.4	—47 01	7.6— 8.5	4 15.3	4 21	14 4	23 11			
V Velorum	9 19.2	—55 32	7.5— 8.2	4 08.9	1 21	10 15	19 8	28 2		
Z Leonis	9 46.4	+27 22	7.9— 9.6	56 08.7				26 21		
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	1 0	7 19	14 14	28 4		
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	6 11	13 1	19 16	26 6		
S Muscae	12 07.4	—69 36	6.4— 7.3	9 15.8	6 2	15 18	25 9			
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	3 20	11 19	19 19	27 18		
T Crucis	15.9	—61 44	6.8— 7.6	6 17.6	3 13	10 6	23 17	30 11		
R Crucis	18.1	—61 04	6.8— 7.9	5 19.8	5 20	11 15	23 7	29 2		
S Crucis	12 48.4	—57 53	6.5— 7.6	4 16.6	5 7	14 16	19 9	28 18		
W Virginis	13 20.9	— 2 52	8.7—10.4	17 06.5	4 10		21 17			
SS Hydræ	25.0	—23 08	7.4— 8.1	8 04.8	7 10	15 14	23 19			
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	4 1	11 2	18 2	25 3		
ST Virginis	14 22.5	— 0 27	10.3—11.4	0 09.9	7 17	15 22	24 4			
V Centauri	25.4	—56 27	6.4— 7.8	5 11.9	3 12	14 11	19 23	30 23		
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 18	10 7	17 21	25 10		
R Triang.Austr.	15 10.8	—66 08	6.7— 7.4	3 09.3	5 7	12 1	18 20	25 15		
S Triang.Austr.	15 52.2	—63 29	6.4— 7.4	6 07.8	2 8	8 16	21 8	27 15		
S Normæ	16 10.6	—57 39	6.6— 7.6	9 18.1	8 13	18 7	28 1			
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	2 5	11 2	19 22	28 19		
RV Scorpii	16 51.8	—33 27	6.7— 7.4	6 01.5	5 10	11 11	23 14	29 16		
X Sagittarii	17 41.3	—27 48	4.4— 5.0	7 00.3	8 7	15 7	22 8	29 8		
Y Ophiuchi	47.3	— 6 07	6.1— 6.5	17 02.9		17 3				
W Sagittarii	17 58.6	—29 35	4.3— 5.1	7 14.3	1 23	9 12	17 3	24 17		
Y Sagittarii	18 15.5	—18 54	5.4— 6.2	5 18.6	3 15	9 10	20 23	26 17		
U Sagittarii	26.0	—19 12	6.5— 7.3	6 17.9	1 13	8 7	21 19	28 12		
Y Scuti	32.6	— 8 27	8.7— 9.2	10 08.3	9 6	19 14	29 23			
RZ Lyræ	39.9	+32 42	9.9—11.2	0 12.3	5 9	11 13	23 19	29 22		
RT Scuti	18 44.1	—10 30	9.1— 9.7	0 11.9	2 20	8 19	20 16	26 15		
κ Pavonis	18 46.6	—67 22	3.8— 5.2	9 02.2	1 2	10 4	19 6	28 9		
U Aquilæ	19 24.0	— 7 15	6.2— 6.9	7 00.6	6 18	13 19	20 19	27 20		

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1924 December					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
XZ Cygni	19 30.4	+56 10	8.6— 9.3	0 11.2	7 19	14 19	21 19	28 19		
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	7 10	15 9	22 9	31 8		
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	4 11	12 4	19 21	27 13		
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	7 21	15 1	22 5	29 10		
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2	8 19	17 4	25 14			
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	4 7	10 14	23 6	29 13		
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3		14 16		31 2		
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	2 13	11 10	20 7	29 4		
UY Cygni	52.3	+30 03	9.6—10.4	0 13.5	2 15	9 9	22 20	29 13		
RV Capric.	55.9	—15 37	9.2—10.1	0 10.7	1 19	8 12	21 22	28 15		
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		10 3		24 20		
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	8 1	15 22	23 18	31 15		
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	5 11	12 8	19 5	26 3		
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4 7	14 0	18 21	28 14		
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	1 4	9 19	18 11	27 3		
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	4 20	15 14	20 22	31 16		
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1	7 22	18 20	29 17			
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	1 11	7 21	20 17	27 3		
V Lacertæ	44.5	+55 48	8.5— 9.5	4 23.6	1 21	11 20	21 19	31 18		
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	2 10	13 18	18 18	29 16		
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	5 1	10 12	21 9	26 19		
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	6 22	13 5	19 13	25 20		
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	6 6	18 9	30 12			
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	1 15	8 15	22 14	29 14		

COMET NOTES.

New Object Discovered by Baade. — A cablegram from Copenhagen to Harvard College Observatory, October 25, announces the discovery of a moving object by Baade at Bergedorff on October 23. The object is described as of magnitude 10. Whether it is a comet or an asteroid is not stated. The discovery position is as follows:

G. M. T.	Right Ascension	Declination
October 23.3094	$21^h\ 05^m\ 16^s$	+15° 28′

The daily motion is given as 4^m 46^s east and 40′ south.

Cloudy weather at Northfield prevents observation of the object before this number of POPULAR ASTRONOMY goes to press. The object was observed by Deporte at Copenhagen October 25.3743 in right ascension $21^h\ 15^m\ 31^s$, declination +14° 07′ 09″.

New Comet *c* 1924 (Finsler).—Announcement of a new comet discovered by Finsler, of Bonn, Germany, came by cablegram from Copenhagen to Harvard College Observatory on September 20. The comet was first observed at Bonn on September 15.

From the *Astronomische Nachrichten* No. 5324 we learn that the comet was found with a field-glass, close by the star 42 *Comae Berenices*. Its brightness was then about fourth magnitude. On September 17 the comet was near *υ* Bootis, and its brightness was estimated at 5^m. A faint tail could be traced to about 4° with the field-glass.

The following observations of the comet have come to hand up to date (Oct. 15).

OBSERVATIONS OF COMET *c* 1924 (Finsler).

G. M. T. Sept.	α h m s	δ ° ′ ″	Observer	Place
15	13 13	+19	Finsler	Bonn
17	13 35	+16	Finsler	Bonn
19.276	13 52 08	+12 07	Prager	Babelsberg
*21.3125	14 09 19.8	+ 8 53 15	Gonnesiat	Algiers
21.6367	14 09 29.80	+ 8 23 43.5	Jeffers	Mt. Hamilton
*22.2921	14 13 48.7	+ 7 24 07	Dyson	Greenwich
22.5709	14 15 29.22	+ 7 00 34.8	Wilson & Gingrich	Northfield
*23.2786	14 19 45.4	+ 5 59 54	Gonnesiat	Algiers
*23.2805	14 19 46.53	+ 5 59 43.6	Vinter-Hansen	Copenhagen
23.5233	14 21 10.6	+ 5 39 09	Bower	Washington
23.5396	14 21 16.3	+ 5 37 47	Van Biesbroeck	Williams Bay
23.6599	14 21 57.85	+ 5 27 45.1	Jeffers	Mt. Hamilton
24.5104	14 26 41.2	+ 4 18 17	Bower	Washington
24.5572	14 26 56.66	+ 4 14 32.0	Gingrich & Wilson	Northfield
24.6485	14 27 25.65	+ 4 07 15.6	Jeffers	Mt. Hamilton
25.5555	14 32 07.58	+ 2 56 29.4	Wilson & Gingrich	Northfield
26.2800	14 35 40.85	+ 2 02 05.9	Vinter-Hansen	Copenhagen
27.2742	14 40 17.88	+ 0 50 33.2	Vinter-Hansen	Copenhagen
28.6548	14 46 13.88	— 0 43 45.9	Jeffers	Mt. Hamilton
30.5441	14 53 37.16	— 2 43 02.3	Wilson & Gingrich	Northfield
30.6422	14 53 58.83	— 2 48 51.9	Jeffers	Mt. Hamilton

The observations marked with an * give apparent positions of the comet. The others are mean positions for 1924.0. The Northfield positions are astrographic, i. e., as they come directly from the photographs, without correction for aberration or parallax.

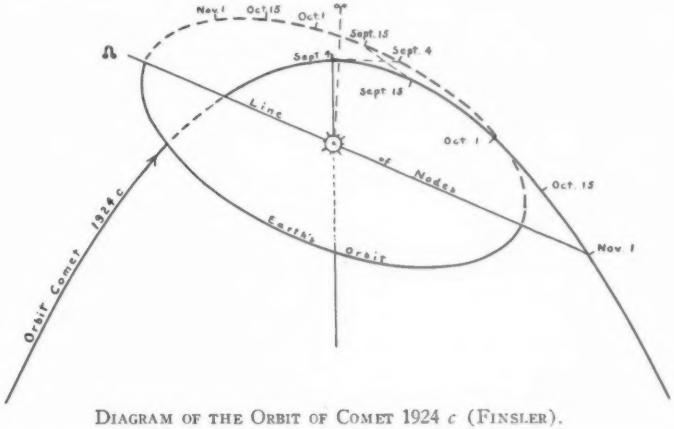


DIAGRAM OF THE ORBIT OF COMET 1924 *c* (FINSLER).

At Northfield the comet was first seen on September 22, when it was barely visible to the naked eye. With the large telescope a short tail could be seen, and a photograph taken with the 6-inch doublet camera revealed a tail about one degree long. Since that date the position of the comet has been growing less favorable for observation and moonlight intervened after October 1.

The accompanying diagram shows the relation of the orbits of the comet and the earth, showing that since the date of discovery the two objects have been

receding from each other quite rapidly, so that no further observations are likely.

Three sets of preliminary elements of the comet's orbit are at hand, the first from a private letter from Mr. L. J. Comrie of Dearborn Observatory, computed by Van Biesbroeck and Comrie; the second from Copenhagen Circular No. 43, computed by J. P. Möller and Bengt Strömgren; the third from the Lick Observatory Bulletin No. 356, computed by A. D. Maxwell, Miss L. Allen and Dr. H. Thiele. The last depends upon observations September 21, 23 and 26 and is probably the more accurate.

ELEMENTS OF COMET *c* 1924 (Finsler)

Computers	Van Biesbroeck and Comrie	Möller and Strömgren	Maxwell, Allen and Thiele	
T =	1924 Sept. 4.333	Sept. 4.559	Sept. 4.33014 G. M.T.	
ω =	66° 28′	66° 26′.5	66° 32′ 40″.2	1924.0
Ω =	80 06	79 05.8	80 05 43.2	1924.0
i =	120 02	121 59.8	120 03 00.0	1924.0
log q =	9.60800	9.61047	9.608538	

The following ephemeris was computed by Mr. Comrie and Miss Gushee from the first set of elements. As the comet is receding so rapidly and going behind the sun, it is probably not worth while to publish an extended ephemeris.

EPHEMERIS.

Date	α h m s	δ ° ′	Log Δ	Log r
Oct. 1.5	14 57 05	— 3 39	0.1225	9.8972
3.5	15 3 47	— 5 30	.1419	9.9178
5.5	15 9 54	— 7 10	.1605	9.9374
7.5	15 15 28	— 8 43	.1784	9.9560
9.5	15 20 37	—10 8	.1954	9.9739
11.5	15 25 25	—11 26	.2117	9.9909
13.5	15 29 55	—12 39	.2273	0.0073
15.5	15 34 9	—13 46	.2422	0.0229
17.5	15 38 9	—14 49	.2564	0.0379

COMMUNICATIONS.

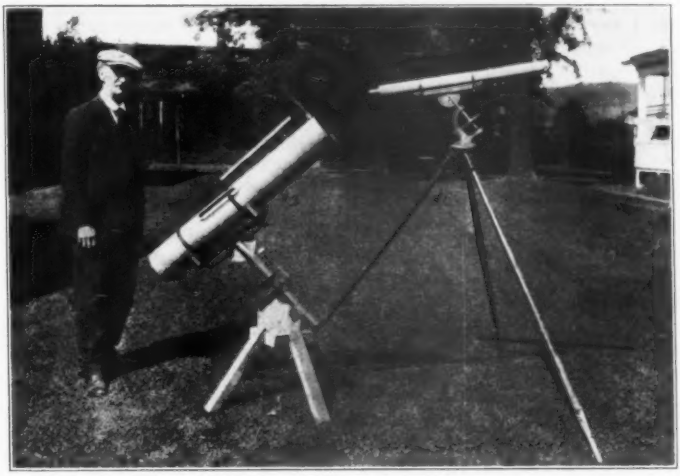
Signals From Mars. — Those who expect to receive signals, or think that they may receive signals from Mars, are in general those who believe that the finer canals are artificial. It is now known that these canals not only are not permanent, but also that they shift both their positions and their directions. If the Martians can shift them at will, then it should be obvious to them, if they are like ourselves, that hte most striking way of calling our attention to their personal existence would be to select some that are conspicuously located, like the four that form a Greek cross in the bright elliptical area Hellas. By causing these to appear, sometimes one and sometimes another, it is clear that signals could be sent which would be seen by us without much difficulty. These canals are now beginning to develop, in connection with the melting polar cap. In the past there has been some variation amongst them, but no sufficiently rapid or striking changes, so far as known, to indicate artificial signals. Since such signals would be readily visible, why should the assumed Martians trouble themselves with wireless, or with any other less obvious method? If the Martians are more advanced than ourselves, as their adherents believe, it is likely, unless

they are phenomenally persevering, that they got tired of signalling to an unresponsive earth several thousand years ago. Therefore why should they signal?

WILLIAM H. PICKERING.

Mandeville, Jamaica, B. W. I., September 4, 1924.

An Amateur's Telescopes. — I am sending you a photograph of my telescopes, a 2½-inch refractor and original equatorial mounting, and a 7-inch reflector, the mirror of which I ground, polished and silvered, the mounting being similar to the other. They are a little rough but they are quite efficient, and



MR. CLARK AND HIS TELESCOPES.
No. 1 a refractor of 2½-inch aperture. No. 2 a reflector with 7-inch mirror.

for portables work very well. Perhaps you might use them in POPULAR ASTRONOMY as showing what two hands and the ordinary household tools, plus a little enthusiasm, can do.

C. H. CLARK.

56 Spring Street, St. Johnsbury, Vt.

The Limelight of the Moon.—In his article "The Limelight of the Moon—An Alternative Theory" Mr. Donald P. Beard, in describing as a vast coral atoll the crater Copernicus, makes use of the expression "almost the counterpart of those in our mundane Pacific Ocean." This seems to me to be particularly apt and suggestive. For does not the supposition that the moon was torn away from the earth from the region of the Pacific Ocean appear to lend support to Mr. Beard's view that the so-called craters are coral formations? It is only the Pacific region that is specially prolific in coral structures, although coral reefs exist in the Indian Ocean and the Red Sea. This might be due to the fact that this portion of the earth presents materials and conditions favorable for the formation of the reefs and atolls. And it is natural to suppose that the

satellite moulded out of substance from the same region is likely to have presented facilities for similar formations on itself when conditions were favorable for the little animals to live and build.

If, on the other hand, independent and direct evidences prove that the lunar craters are really coral formations, will it not then strengthen the suggestion that the satellite came out of the earth from the Pacific bed?

P. R. CHIDAMBARA IYER.

Kodaikanal Observatory, South India, July 22, 1924.

A Bright Fireball. — On the night of Sept. 9 at 11:35 o'clock Pacific Time, I saw a magnificent meteor or fire-ball. It swept slowly across the sky from the region of Cetus a little east of north, and passed from view about five degrees east of Aldebaran, behind a house. The meteor was so large that it showed a well-defined disk, and shone with a brilliant white glare in spite of the effulgence of the moon at its ten-day phase. With its attendant train of sparks, it was a beautiful and majestic spectacle.

ROBERT E. MILLARD.

1014 Council Crest Drive, Portland, Oregon.

The Teaching of Astronomy. — Sometime ago the following questionnaire was sent to 250 observatories and institutions teaching astronomy throughout the world. 70 were sent to foreign countries.

Replies were received from 135 institutions representing 37 of our States and 16 foreign nations.

1. In your estimation, is astronomy increasing in popularity?
2. What do you consider to be the greatest need in Astronomy today?
3. What is your present enrollment in astronomy?
4. How many instructors have you?
5. Are your publications available for general distribution?
6. What text-book do you use in astronomy?
7. What laboratory manual?
8. Please outline your laboratory experiments in astronomy on the other side of this letter. We would be glad to have this outline as complete as possible.

The questions were answered as follows:

1.

Yes	No	About the Same	No Answer
45%	15%	5%	35%

2. Money and endowment (8)
   Better texts (6)
   Better trained teacher (4)
   Emphasis on descriptive rather than the mathematical side (4)
   Universal teaching of astronomy in high school (4)
   More popular instruction (3)
   Equipment (3)
   Stimulation of interest in public schools (3)
   Popularization of known material (3)
   A proper appreciation of the science by the public, heads of colleges, trustees, and members of faculties (3)
   Better foundation in mathematics and physics (3)
   Verification of Einstein Theory (2)

Publicity (2)
Better understanding of its value as a cultural subject (2)
Equipment in Southern Hemisphere.
Men and women of unusual ability to interpret results of observations.
Less of commercial spirit among students and educators.
Primarily—additional research, secondarily—a general educational campaign.
Some books on the subject not too technical, not to simple.
Student observatories.
To present it interestingly—not as a mere descriptive or mathematical course.
Education of the public to the fact that some things are worth knowing which cannot be measured in dollars and cents.
A good manual of exercise—laboratory work.
More chances for prospective astronomers to make a living.
A more universal knowledge and use of instruments of observation in first course.
Investigation in the structure of the Stellar Universe.
Serious students who are willing to think.
The study of the sun and its radiation.
Clear weather.
Improved education.
Establishment of Astronomical Clubs.
More accurate observations.
Careful research—adequate and rapid publication of results.
International Committee to collect funds for the science.

3. None to several hundred.
4. None to five.
5. 25%, yes.

6 and 7. In the majority of institutions.
General—Young Manual or Moulton.
Practical—Hosmer or Campbell.
Theoretical—Moulton or Watson.
Laboratory Manual—Willson, Byrd or Whiting.

8. In answer to this question various lists of exercises were received from institutions giving laboratory work in astronomy.
After a careful examination of this information we have selected a list of 70 exercises for our students in beginning astronomy. 30 must be completed each semester. This gives the student a choice of exercises, which is almost necessary on account of the uncertainty of weather conditions.

The following will serve as examples of the exercises selected:

1. Transit of Mercury, May 7, 1924.
2. Eclipse of Sun, Jan. 24, 1925.
3. Plot the paths of the planets for 1924.
4. Find the sun's meridian altitude on twelve different dates. (Two methods.)
5. Find time by 3 kinds of Sun dials.
6. Sketch Saturn and Jupiter (3 dates)
7. Determine the latitude of the observatory from the latitude of Polaris (Use transit)

8. Determine the latitude of the observatory from the altitude of the sun at noon. (Use sextant and artificial horizon)

In conclusion, I wish to thank all instructors and astronomers whose replies have made these results possible.

O. L. DUSTHEIMER,
Professor of Mathematics and Astronomy.

Baldwin-Wallace College,
Berea, Ohio.

An Interesting Experiment for the amateur to perform is to walk down a hill rapidly, fixing his eye on some bright star. Venus, for instance, is a fine object to experiment with. The star or planet will seem to move rapidly down, and at the same time remain practically stationary in the part of the sky where it is situated. This is a fine optical illusion and I have often entertained my friends with this experiment.

SAMUEL CRAMER.

49 Arlington St., Worcester, Mass.

GENERAL NOTES

Professor Edgar Lucien Larkin, for many years director of the Observatory on Mount Lowe, near Pasadena, California, died on October 11, 1924, at the age of 77 years. Professor Larkin did much to popularize Astronomy with the thousands of excursionists who visited the Mount Lowe Observatory each year, and with the public through simple articles in the daily newspapers.

Civil Service Examination in Astronomy. – The United States Civil Service Commission announces the following open competitive examination:

JUNIOR SCIENTIST (ASTRONOMER).

An examination for junior scientist (astronomer) will be held throughout the country on December 3 and 4. It is to fill vacancies in the Naval Observatory and in the Nautical Almanac Office, Washington, D. C., at an entrance salary of $1,860 a year. Advancement in pay may be made without change in assignment up to $2,400 a year.

Applicants must have been graduated from a college of recognized standing. For each year lacking in the college course there may be substituted a year of experience in astronomic work, either as computer or observer, the whole advancing in accomplishment and content comparable to the progression of a complete college course and providing broad fundamental training in astronomy.

In selecting eligibles for these positions in the Naval Observatory preference will be given to men who have had experience in the use of astronomical, physical or engineering instruments.

Competitors will be rated on mathematics, astronomy, practical computations, and French or German.

Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post office or customhouse in any city.

Items from the Yerkes Observatory for Popular Astronomy.

Dr. Frank E. Ross, who has been for the past nine years a member of the staff of the Research Laboratory of the Eastman Kodak Company at Rochester, has been appointed Associate Professor of Practical Astronomy in the University of Chicago. His work will be at the Yerkes Observatory and he took up his residence at Williams Bay, Wisconsin, on October 1.

For the present, Professor Ross will chiefly use the Bruce Photographic Telescope, which was so successfully employed by the late Professor Barnard, and it is expected that a new lens, designed by Dr. Ross, will be substituted for the 6¼-inch portrait lens hitherto used.

Dr. Henri L. Vanderlinden, of the Royal Observatory at Uccle near Bruxelles, Belgium, who has been at the Mount Wilson Observatory for the past year, has arrived at the Yerkes Observatory for a stay of some months as Volunteer Research Assistant.

Mr. Nicholas T. Bobrovnikoff, who has been for the past three years a student at the Russian University at Prag, has begun work at the Yerkes Observatory as a graduate student in the University of Chicago.

Professor Storrs B. Barrett received the honorary degree of D. Sc. from his Alma Mater, the University of Rochester, at Commencement, 1924.

During the Summer Quarter the following were occupied in graduate work at the Yerkes Observatory: William H. Garrett, Professor of Mathematics and Astronomy of Baker University, Baldwin City, Kansas; William A. Luby, Professor of Mathematics in the Junior College of Kansas City, Missouri; and Edward M. Justin, Instructor in Mathematics and Astronomy at the Case School, Cleveland, Ohio.

Dr. Alice H. Farnsworth of Mount Holyoke College spent two weeks at the Observatory in August in work on stellar photometry.

Recent visitors at the Observatory were: Professor Jean Mascart, Director of the Observatoire de Lyon, France, with Madame Mascart; Professor J. Bosler, Director of the Observatoire de Marseille; Mr. and Mrs. Svein Rosseland, of Norway; Dr. John Jackson of the Royal Observatory, Greenwich, with Mrs. Jackson; Mr. Piet van de Kamp of Holland, who has spent the last year and a half at the McCormick Observatory, University of Virginia, and becomes Martin Kellogg Fellow at the Lick Observatory for the current year. Mr. W. J. Showalter, Associate Editor of the National Geographic Magazine, who was collecting material for an astronomical article in that magazine, spent several days in August at the Observatory.

—E. B. F.

Third Catalogue of Spectroscopic Binary Stars.— Number 355 of the *Lick Observatory Bulletin* contains a new catalogue of spectrographic binary stars compiled at the Lick Observatory, bringing up to date (July 1, 1924) the principle data concerning the stars which have been shown to be physical systems by means of the periodic shift in the lines of their spectra. The "Second Cata-

logue of Spectroscopic Binary Stars" was issued by Professor Campbell in 1910. Since that time the number of known spectroscopic binaries has increased from 306 to 1054, while in the same period the number of well-determined orbits has increased from 71 to 248.

The present catalogue has been prepared for publication by Dr. J. H. Moore. In the introduction he makes the following very significant statement:

"The assumption that the variable velocity of a star is evidence of its orbital motion in a binary system appears in general to be justified. However, as a result of the more intimate study of the phenomena exhibited by certain classes of stars listed as spectroscopic binaries, evidence has been accumulated within recent years that we may not be justified in so interpreting all cases of variable radial motion. Thus, grave difficulties have been encountered in the interpretation of Cepheid variables as binary systems and the hypothesis has been advanced and ably supported that the observed variable velocity is due to pulsations of a single star. In the present state of our knowledge it appears the part of wisdom to continue the policy of including these stars in a list of spectroscopic binaries, although in statistical studies they should be excluded or at least treated separately."

Contributions from the Princeton University Observatory No. 6.—In this contribution of 66 pages, Dr. Dugan reports on his photometric researches on five eclipsing variables of the Algol type. The light-curves given show clearly defined secondary minima in the cases of SZ Herculis, RS Vulpeculae, R Canis Majoris and RY Aquarii, but none in the case of Y Camelopardalis. The reviewer made a rough count of the total number of observations given for the five stars. This amounts to 3176. Furthermore, since one observation of Dr. Dugan's is the mean of sixteen individual settings, this contribution means the making of nearly 50,000 separate comparisons, after which come the tabulation and computations, the latter taking much longer than the observations. *Contributions* No. 6 represents a vast amount of work of a high order of accuracy.

Rotation of Brighter Component of Beta Lyrae.—The first definite evidence of the actual rotation of a star other than the sun has been obtained by R. A. Rossiter, a graduate student at the University of Michigan. It is evident that if the darker star of an eclipsing pair has almost covered the brighter one, and, if the latter has a rotation about an axis which is approximately perpendicular to the plane of the orbit, the narrow crescent of the brighter star which is still visible will have a rotation component along the line of sight and the lines of the spectrum of this crescent will be shifted. Just after the completion of the total phase of the eclipse a crescent of the brighter star is uncovered on the side opposite to the first crescent and, since the rotation component of its motion will be in the opposite direction, its spectral shift will be opposite to the first shift. If the darker star is so faint that its spectrum does not register on the plate the problem is comparatively simple, but if this is not the case the lines of both components are blended and the results are more difficult to disentangle.

On the basis of a study of 442 spectrograms of Beta Lyrae, taken at the Detroit Observatory of the University of Michigan, Dr. Rossiter succeeded in disentangling a rotational effect from the blended lines of the two components of this famous variable star. While it is almost certain, from the nature of the

case, that the stars rotate, yet it is a distinct achievement to produce a real proof even though it is only for a simple case. Another point also determined is that Beta Lyrae is a simple binary system, that is, there is no third star sufficiently near to affect its motion. Dr. Rossiter's paper will be found in the *Astrophysical Journal* for July, 1924.

A Spectroscopic Study of Algol. — In the same number of the *Astrophysical Journal* containing Dr. Rossiter's paper there is another of great interest on Algol, because a rotation effect has been found for the brighter component of the "Demon Star" as well. Dr. Dean B. McLaughlin, the author of this second paper has based his study on 156 spectrograms also taken at the Detroit Observatory. Other results are a redetermination of the orbital elements of the bright star, as well as a redetermination of the long-period orbit, showing that there is a third body in the system, about which the eclipsing pair is revolving in a period of 1.885 years. On the basis of spectroscopic and photometric material the parallax of Algol is found to be 0".031, corresponding to a distance of 32 light years. The most important result in the paper, in the opinion of the reviewer, is the finding of the rotational effect. We now have good evidence that at least two stars have axial rotation.

History of the Royal Astronomical Society, 1820-1920. — This volume, the work of six authors, is one of the most readable books the reviewer has read in some time. The authors, H. H. Turner, J. L. E. Dreyer, R. A. Sampson, E. H. Grove-Hills, H. F. Newall and H. P. Hollis, each wrote the history of a decade, thus covering the years 1820-1880. J. L. E. Dreyer then treated the period 1880-1920 in the final chapter.

The history of the Royal Astronomical Society is almost a history of modern astronomy. We find the names of William and John Herschel, Airy, Adams, Huggins and Gill, as a few of its illustrious members who served not only as presidents of the society but also made great contributions to astronomy during their life.

The early troubles of the society, its attitude toward the Adams-Le Verrier controversy, the difficulties in awarding the gold medal on certain occasions and many other incidents in the life of the society, afford interesting glimpses of the men who were the leaders in British astronomy. The generous recognition of the work of astronomers in other lands and the omission of any word of ill-feeling because of the world war are refreshing to note. If we remember correctly, the Royal Astronomical Society was one of the few organizations sufficiently broad-minded not to drop from its membership fellows and associates of enemy countries.

We must congratulate the Society, not only for completing a century of effort in behalf of astronomical science, but also for having placed this record of its achievements before the world in such a delightful volume.

Occultation of Regulus. — The occultation of Regulus was observed with a perfectly clear sky at Northfield on the morning of October 23. Two classes of students, equipped with small telescopes and field-glasses watched the phenomenon with great interest. The time of immersion was noted by two students, one using the chronograph, the other listening to the count of

seconds from a ship watch. The time of emersion was noted by Professor Wilson with the 16-inch telescope and chronograph, by two students with field-glasses, listening to the beats of a chronometer, and by eight students with small telescopes, listening to the count of seconds by Professor Fath with the ship watch. The agreement of the results is excellent.

	Central Standard Time			
	h m s			
Immersion	4 30 55.5	A. M.	Ship watch	1 student
"	4 30 54.6	"	Chronograph	1 student
Emersion	5 36 25.4	"	Chronometer	2 students
"	5 36 25.7	"	Ship watch	8 students
"	5 36 25.8	"	Chronograph	Wilson
Emersion of 7m star preceding Regulus	5 28 07.8	"	Chronograph	Wilson

At Providence, R. I.—Observed the immersion of the occultation of α Leonis (Regulus) as occurring at $5^h\,58^m\,23^s$ A. M. this morning—Eastern Standard Time. I believe this is within ¾s of being correct.

Donald B. Prentice.

178 Doyle Avenue, October 23, 1924.

At North Scituate, R. I.—The occultation of α Leonis (Regulus) was observed at the Seagrave Observatory here under very good conditions. The sky was clear and with the exception of daylight on the emersion observation, the seeing good.

Immersion occurred	$5^h\,58^m\,24^s.5$ E. S. T.
Emersion "	$7^h\,13^m\,42^s.5$ E. S. T.

The observation of emersion time may be off slightly, as daylight made it hard to determine the exact instant of reappearance. Barometer steady at 29.9—thermometer 31° F.—light N. W. wind.

October 24, 1924. Lewis J. Boss.

THE OLD AMATEUR.

What matters it that, weary and alone,
I sit and think of things I might have done?
What matters it that wife and children shun
In me a dreamer, a mere rolling stone?
What matters it that rustic neighbors fear
In me a madman, all because I know
The motions of the comets and the flow
Of time, that travels on from year to year?
What matters it? There are far better men
To count the days and aeons, as they run,
And weigh this planet that we dwell upon.
But yet, I feel it matters somewhat, when—
What matters it?——I see, across the wire,
The transit of the star of my desire.

R. Burnside Potter.

Smithtown, Long Island.